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JOURNAL of PALEONTOLOGY

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THE FUSULINID GENUS *STAFFELLA* IN AMERICA

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ABSTRACT

Ten species and one variety of fusulinids which are definitely referable to the genus *Staffella* are known, and five other congeneric forms have been referred to these species, perhaps incorrectly. All of these come from rocks of Lower Pennsylvanian age in Europe, Asia, and North America. Five additional species that may represent this genus have been described. These range in age from Mississippian to Permian. The genus *Staffella* is discussed at some length in this paper. The genotype is renamed and two new species and one new variety from the Lower Pennsylvanian of Oklahoma and Colorado are described. A new generic name, *Ozawainella*, is proposed for a closely related form, *Fusulinella angulata* Colani, of the Permian(?) of French Indo-China.

It has been generally believed that the genus *Staffella* is the ancestral form of the Fusulinidae, and therefore it merits special consideration. Although this genus has long been known from Europe and Asia, it is only very recently that representatives of it have been reported from North America. Eight species which definitely represent this genus have been described from different parts of the world—one from Europe, six from Asia, and one from North America. Four other species are known which may be congeneric—one from Europe, two from Asia, and one from North America. Also two forms from North America have been referred to an Asiatic species of this genus, and two Asiatic forms have been referred to a European species. All four of these probably represent distinct species, and the forms that have been described from Armenia probably represent two species rather than one, as has heretofore been believed. Most of these seventeen representatives of *Staffella* are among the earliest known members of the Fusulinidae, and hence their stratigraphic position is in harmony with the belief that they are ancestral to the other members of this family. The discovery of two new species and one new variety of *Staffella* in some of the oldest fusulinid-bearing rocks in North America is well worth recording.

In 1912 Staff[1] mentioned the occurrence in the "Permian (?)" of California of an indeterminable species which he referred to the genus *Fusulinella*. He[2] had previously defined this genus to include only spheroidal and lenticular types of fusulinids, but it is not possible to determine from

[1] Staff, H. von, Monographie der Fusulinen, Teil III, Die Fusulinen (Schellwienen) Nordamerikas: *Paleontographica*, Bd. 59, pp. 161, 164, 1912.

[2] Staff, H. von, Beiträge zur Kenntnis der Fusuliniden: *N. Jahrb. f. Min., Geol. u. Pal.*, Beilageb. 27, pp. 461–508, 1909.

his brief mention which of these types he was studying from California. If it was a spheroidal form, it may well have been a *Staffella*. With the possible exception of this form, no representatives of this genus were described from America until 1928. In that year Harlton[3] referred three species from the Pennsylvanian of Texas to *Staffella*. Two of these species, *S. formosa* and *S. ciscoensis*, certainly do not represent this genus as they are not closely related to its genotype, and the third species, *S. texana*, is so illustrated and described that its generic affinities cannot be determined without a restudy of the original material or good topotypes, neither of which is available to me at present. Later in 1928 Galloway and Harlton[4] described a form from the upper Glenn (Hoxbar) formation of Oklahoma. This is the first species described from America that I can assign without question to *Staffella*, but the authors referred their form to an Asiatic species, *S. mölleri* Ozawa, with which it probably is not conspecific. Their illustrations are drawings of two external views and of a sagittal section, and unfortunately these are not suitable for detailed specific comparisons. In 1930 Galloway and Ryniker[5] described a *Staffella* from the lower part of the Atoka formation of Oklahoma and referred it to *S. mölleri* Ozawa. This form also is very probably not conspecific with the Asiatic type specimens, but as it is illustrated only by two drawings of external views, I am not able to determine its specific affinities with certainty. In 1930, Roth and Skinner[6] described as *Staffella keytei* a representative of this genus from the McCoy formation of Colorado, and they also listed a second species from the upper part of the same formation that may be congeneric. In so far as I have been able to determine, no other representatives of *Staffella* have been described from North America.

Recently Mr. R. V. Hollingsworth of the University of Chicago sent me several excellent collections of fusulinids from Lower Pennsylvanian rocks in Oklahoma and Colorado. These contain well preserved representatives of *Staffella* from five localities representing four horizons. The minute structure of the spirotheca and the development of internal structures can be seen clearly in some of these specimens. They represent at least two new species and one new variety. One of the new species, which I am describing below as *S. atokensis*, is based on specimens from two horizons: (1) about 100 feet and (2) about 200 feet above the base of the Atoka formation of Oklahoma. The other new species, *S.*

[3] Harlton, B. H., Pennsylvanian Foraminifera of Oklahoma and Texas: *Jour. Paleontology*, vol. 1, pp. 305–310, 1928.

[4] Galloway, J. J., and Harlton, B. H., Some Pennsylvanian Foraminifera of Oklahoma, with special reference to the genus *Orobias*: *Jour. Paleontology*, vol. 2, pp. 338–357, 1928.

[5] Galloway, J. J., and Ryniker, Charles, Foraminifera from the Atoka formation of Oklahoma: *Oklahoma Geol. Survey, Circ.* 21, p. 21, 1930.

[6] Roth, Robert, and Skinner, John, The fauna of the McCoy formation, Pennsylvanian, of Colorado: *Jour. Paleontology*, vol. 4, pp. 332–352, 1930.

hollingsworthi, is only known to occur in the upper portion of the Boggy formation of Oklahoma, and the specimens which I am regarding as a new variety of *S. keytei* come from the lower portion of the McCoy formation of Colorado.

I wish to take this opportunity to acknowledge my indebtedness to Dr. A. K. Miller, who has read the entire manuscript and has offered many valuable criticisms, and to Mr. R. V. Hollingsworth for the opportunity to study this material.

SYSTEMATIC DESCRIPTIONS

Genus STAFFELLA Ozawa

In 1925 Ozawa[7] established the genus *Staffella* and designated as its genotype *Staffella sphaerica* v. Möller. *Fusulina* [*Staffella*] *sphaerica*, originally described by Abich,[8] was based on specimens from the Upper Carboniferous of Armenia, and in 1928 Ozawa listed *Fusulina sphaerica* Abich as the genotype of *Staffella*. The specimens referred by Möller[9] to Abich's species also came from Armenia, but they differ considerably from those figured by Abich. Möller believed this variation to be due entirely to differences in preservation, but I am convinced that that is not the case and that the specimens described and illustrated by Möller are specifically distinct from those figured by Abich. Since, as has been noted by Dunbar,[10] the genus *Staffella* must be regarded as based on the specimens described and illustrated by Möller and not those studied by Abich, the genotype of *Staffella* is without a valid specific name and I here proposed to call it *Staffella moellerana*[11] (see Pl. 13, figs. 19–23). Ozawa originally defined the genus so that it included the lenticular and spheroidal fusulinids of which the axis of coiling is the shortest diameter and which have a spirothecal structure like that of *Fusulinella;* that is, composed of an upper tectorium, a tectum, a diaphanotheca, and a lower tectorium. Lee[12] observed in 1927 that it would perhaps be best to place the lenticular and spheroidal forms in separate sub-genera and he proposed to call the lenticular forms *Ozawaina;* however, he did not designate a sub-genotype nor did he refer any species to his sub-genus. Galloway and Harlton[13] suppressed *Ozawaina* as a synonym of *Orobias* Eichwald[14] and

[7] Ozawa, Y., On the classification of Fusulinidae: *Imp. Univ. Tokyo, Jour. Coll. Sci.*, vol. 45, art. 4, p. 24, 1925.

[8] Abich, H., Vergleichende Grundzüge der Geologie des Kaukasus wie der armenischen und nordpersischen Gebirge: *Acad. Imp. Sci. St. Pétersbourg, Mém.*, 6th sér. (Sci. Math. et Phys.), tome VII[e], pp. 439, 528, pl. 3, figs. 13*a*–13*c*, 1859.

[9] Möller, V. von, Die spiral-gewundenen Foraminiferen des russischen Kohlenkalks: *Acad. Imp. Sci. St. Pétersbourg, Mém.*, 7th sér. tome XXV, no. 9, pp. 114–117, pl. 5, figs. 6*a*–6*c*, pl. 15, figs. 3*a*–3*b*, 1878.

[10] Dunbar, C. O., in Cushman, J. A., *Foraminifera*, p. 131, 1933.

[11] The figured cotypes of this species and those of *Staffella sphaerica* (Abich) attain more than twice the size of any other known representative of *Staffella*, and since some of the internal structures, such as chomata, have never been illustrated or described in these two species, it is quite possible that the small forms from the Lower Pennsylvanian of many parts of the world that are referred to *Staffella* may not be congeneric with the type of the genus *S. moellerana*. Lee (*Nat. Research Inst. Geol., Mem.*, no. 14, p. 19, 1933) has compared *S. moellerana* to the genotype of *Eoverbeekina* Lee, *E. intermedia* Lee, of the Permian of China.

[12] Lee, J. S., Fusulinidae of North China: *Palaeontologia Sinica*, ser. B, vol. 4, fasc. 1, p. 13, 1927.

[13] Galloway, J. J., and Harlton, B. H., Some Pennsylvanian Foraminifera of Oklahoma, with special reference to the genus *Orobias: Jour. Paleontology*, vol. 2, p. 348, 1928.

[14] This name was proposed by Eichwald in 1849 (*Lethaea Rossica*, vol. 1, pp. 352–354) and he referred to it two species, *Nummulina antiquior* Rouillier and Vosinsky and *Orobias? aequalis* Eichwald.

correctly designated as the genotype of *Orobias* the first species (the only one originally referred to the genus without question) described under that generic name, *O.* [*Nummulina*] *antiquior* (Rouillier and Vosinsky) of the Lower Pennsylvanian of Russia. In 1933 Galloway[15] designated this same species as the type of *Ozawaina*, and since no species had heretofore been referred to it, *Ozawaina* must be regarded as a synonym of *Orobias*, which has priority. It is clear from a study of Eichwald's original diagnosis of *Orobias*, and his footnote reference to it, that he based his genus on only part of the cotypes of *Nummulina antiquior* as described and illustrated by Rouillier and Vosinsky. He referred only to Rouillier and Vosinsky's figures 69 and 77 (*Soc. Imp. Natur. Moscou, Bull.*, vol. 22, no. 2, pp. 337–346, pl. K) and hence we must consider them as representing the genotype. The specimen illustrated by Rouillier and Vosinsky as their figure 69 (as well as that illustrated by their figure 77) is clearly not conspecific with all of the other specimens referred originally to this species. It seems evident that this specimen (figure 69) is not closely related to the family Fusulinidae, and it is even possible that it is not organic. Since this specimen, on which the genus *Orobias* rests, is specifically distinct from some of the other cotypes, I am here designating it as the holotype of *Nummulina antiquior*.

The lenticular forms which have been referred to the family Fusulinidae seem to me to be divisible into two distinct groups. One of these is represented by *Fusulinella bradyi* Möller of the Lower Pennsylvanian of Miatschkowa, Russia. This form is characterized by a subangular periphery and incipient chomata. The second group is represented by *Fusulinella angulata* Colani of the Permian(?) of French Indo-China and is characterized by a very sharply angular periphery, a uniform lateral slope, a narrow tunnel, very well developed chomata, and a very large form ratio. The first of these groups has formerly been placed in the genus *Orobias* Eichwald (= *Ozawaina* Lee). However, in view of the fact that the type of that genus is not planispiral, and possibly not organic, we cannot use this name to designate these forms. Externally *F. bradyi* resembles the type of *Nummulostegina* Schubert, *N. velibitana* Schubert, and the first group of forms, that have been placed erroneously in *Orobias*, may be referable to *Nummulostegina*. The second group, however, is clearly without a valid generic name and I am therefore establishing the new genus *Ozawainella* for them, with *Fusuli-*

[15] Galloway, J. J., *A manual of Foraminifera*, p. 396, 1933.

EXPLANATION OF PLATE 13

FIGS. 1–5—*Staffella hollingsworthi* Thompson, n. sp. 1 and 5, Sagittal sections, ×40; 2 and 4, external views, ×30; 3, axial section, ×40. From the Boggy formation of Oklahoma. Univ. Iowa nos. 842–845. (p. 119)

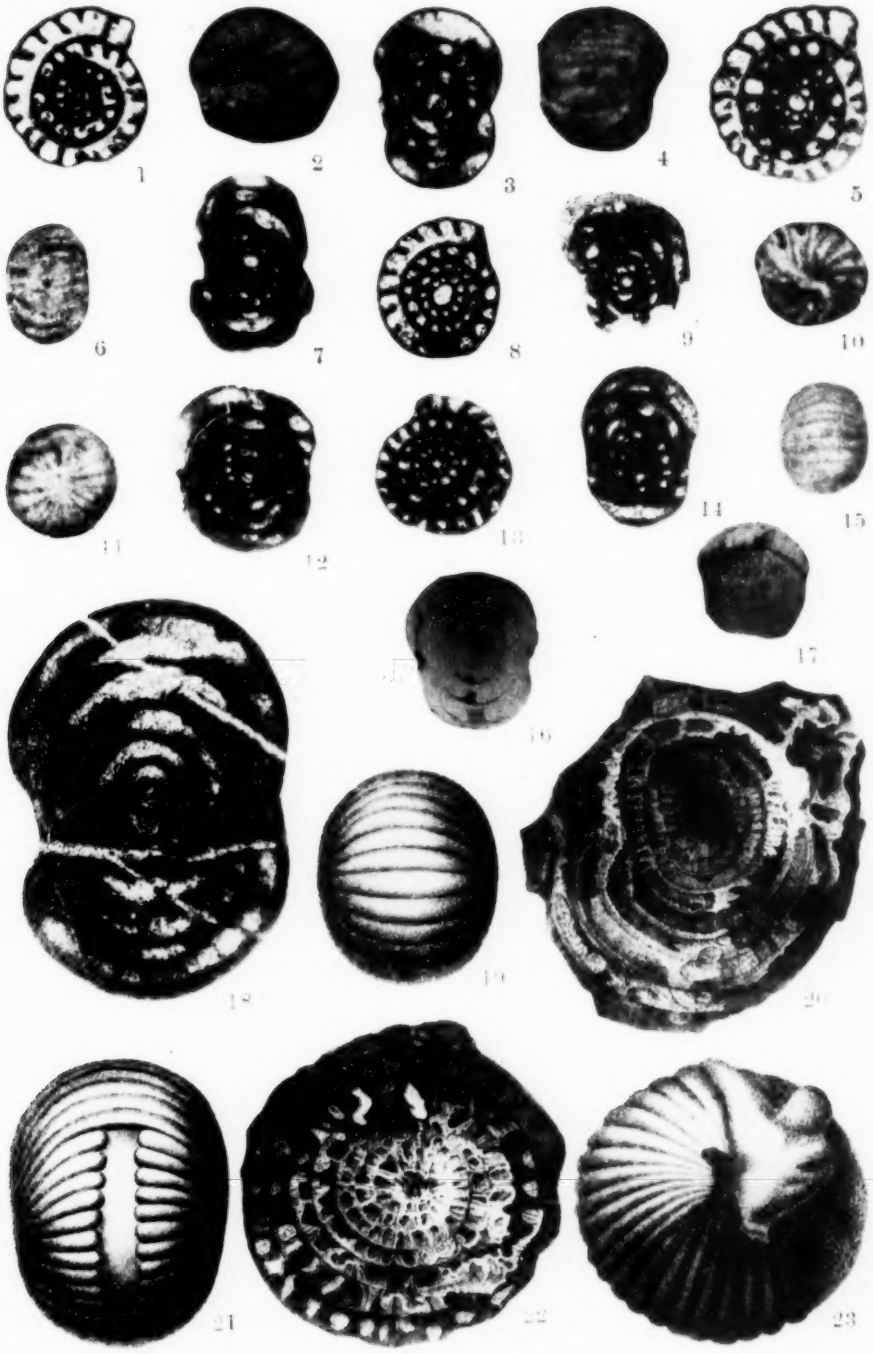
6–10—*Staffella atokensis* Thompson, n. sp. 6 and 10, External views of weathered specimens, ×30; 7 and 9, axial sections, ×40; 8, sagittal section, ×40. From the Atoka formation of Oklahoma. Univ. Iowa nos. 830–833. (p. 117)

11–15—*Staffella keytei maccoyensis* Thompson, n. var. 11 and 15, External views, ×30; 12 and 14, axial sections, ×40; 13, sagittal section, ×40. From the McCoy formation of Colorado. Univ. Iowa nos. 836–839. (p. 118)

16–17—*Staffella keytei* Roth and Skinner. 16, Axial section, ×32; 17, external view, ×20. From the McCoy formation of Colorado. (After Roth and Skinner.) (p. 112)

18—*Staffella mölleri* Ozawa. Axial section, ×45. From the Moscovian of Japan. (After Ozawa.) (p. 112)

19–23—*Staffella moellerana* Thompson, n. sp. 19, 21 and 23, External views, ×10; 20, axial section, ×16.5; 22, sagittal section, ×16.5. From the Upper Carboniferous of Armenia. (After Möller.) (p. 113)



Thompson, Pennsylvanian Fusulinids

nella angulata Colani[16] as the genotype. Representatives of *Ozawainella* may be distinguished readily from those of *Nankinella* Lee (genotype *Staffella discoides* Lee) by their more sharply angular periphery, their better developed chomata, and by the mode of growth of the shell.

In 1842, Ehrenberg described for the first time a representative of the genus *Staffella* s. s. He called it *Melonia* (*Borelis*) *sphaeroidea*. Ehrenberg's description of this species is very brief and generalized, and it was not until 1878 that the details of the structure of the spirotheca of *Staffella* and other characters by which fusulinid genera are now classified were recorded. In that year Möller published detailed descriptions of *Fusulinella* [*Staffella*] *sphaeroidea* (Ehrenberg) and of other specimens which he referred to *Fusulinella sphaerica* (Abich) but which are clearly distinct from the types of that species and are named *Staffella moellerana* above. At the same time he observed that the spirotheca of the spheroidal forms has a structure much like that of *Fusulinella bocki*, the genotype of *Fusulinella*, and accordingly he referred them to his genus *Fusulinella*.

The following species seem to me to be more closely related to *Staffella moellerana* than to any other described genotype and therefore I am referring them to *Staffella: Melonia* (*Borelis*) *sphaeroidea* Ehrenberg[17] of the Lower Pennsylvanian of Russia; *Fusulina sphaerica* Abich of the Pennsylvanian of Armenia; *Fusulinella quadrata* Deprat of the Lower Pennsylvanian of French Indo-China; *Fusulinella umbilicata* Colani of French Indo-China; *Staffella mölleri* Ozawa of the Lower Pennsylvanian of Japan; *Staffella confusa* Lee and Chen, *S. ozawai* L. and C., *S. para-sphaeroidea* L. and C. of the Lower Pennsylvanian of southeastern China; *Staffella keytei* Roth and Skinner of the Lower Pennsylvanian of Colorado; and the forms described below as *Staffella hollingsworthi* from the Boggy formation of Oklahoma, *S. atokensis* from the Atoka formation of Oklahoma, and *S. keytei maccoyensis* from the McCoy formation of Colorado. The illustrations of *Staffella yobarensis* Ozawa of the Lower Permian of Japan resemble very closely typical representatives of *Staffella* and the species may belong to this genus, but the illustrations suggest that it is more closely related to *Sphaerulina crassispira* Lee of the Lower Permian of China, which is the genotype of *Sphaerulina* Lee. Also, *Staffella texana* Harlton of the Upper Pennsylvanian of Texas may be a *Staffella*, but this cannot be determined from the existing illustrations and description. The form from the Pennsylvanian of the Carnic Alps described by Schellwien as *Fusulinella laevis* probably belongs to *Staffella*, but it is only illustrated by two drawings of external views and its internal structures are not fully described. The form from the upper

[16] Colani, M., Nouvelle contribution à l'études des fusulinidés de l'Extreme-Orient: *Service Géol. l'Indochine, Mém.*, vol. 11, fasc. 1, pp. 74–75, 132–133, pl. 2, figs. 16–18, 20, 21, 26, 35, 1924.

[17] Ehrenberg originally described this species in 1842 (*Verhandl. Köni. Preuss. Akad. Wissensch. zu Berlin*, pp. 273–275) and based it on specimens collected by Kayserling and Blasius from the Lower Pennsylvanian of Wetigra, Russia, but he did not illustrate the types until 1854. The only illustrations which in 1854 he did not refer with question to this species were those of specimens from "Gelber Melonien-Jurakalk vom Kaiserstuhl, Baden" and these were designated *Borelis* (*Melonia*) *sphaeroidea* (Mikrogeologie, pl. 37, figs. 9, A, 1–3). The specimens from the Lower Pennsylvanian of Wetigra, Russia, collected by Kayserling and Blasius, were illustrated by Ehrenberg in 1854 (Mikrogeologie, pl. 37, figs. 10, D, 1–4) and were referred to this species with question (*Borelis sphaeroidea?*); nevertheless, they almost certainly formed the basis for Ehrenberg's original description of the species, and they must be considered the types. The form described by Ehrenberg in 1843 as *Borelis labyrinthiformis*, of which he illustrated an axial section in 1854, is most probably a representative of this genus, but it may be conspecific with *Staffella sphaeroidea*. *Borelis palaeosphaera*, also illustrated by Ehrenberg in 1854, may be a representative of this genus but this cannot be determined from the published illustrations.

Glenn (Hoxbar) formation of Oklahoma that Galloway and Harlton referred to *Staffella mölleri* Ozawa and the form from the lower portion of the Atoka of Oklahoma that Galloway and Ryniker referred to *Staffella mölleri* Ozawa are representatives of this genus. They are probably distinct from each other and may be distinct from any of the species listed above, but they may possibly be conspecific with *S. hollingsworthi* and *S. atokensis*, respectively. In 1927, Lee described and illustrated some specimens from the Lower Pennsylvanian of South Manchuria as *Staffella sphaeroidea* (Ehrenberg), and three years later Lee and Chen described and illustrated as *Staffella sphaeroidea* Möller some specimens from the Huanglung limestone of southeastern China. The specimens from the Huanglung limestone seem to me to be specifically distinct from the specimens illustrated from South Manchuria and each probably represents a distinct species which is at present without a valid specific name. Lee and Chen placed *Staffella quadrata* (Deprat) in synonymy with *Staffella sphaeroidea* (Ehrenberg). These two forms are somewhat similar and they are probably closely related, but it seems to me that for the present at least they should be regarded as distinct species. *Fusulinella umbilicata* Colani is somewhat questionably referred to *Staffella*. This species has a much larger form ratio than most of the other species here referred to *Staffella*, but it is possible that the specimens on which it is based are distorted; also, the periphery of its test is more nearly subangular than is that of any of the other species mentioned above. Roth and Skinner listed a form from the upper part of the McCoy formation of Colorado as "*Staffella* sp. large" that may represent this genus, and Staff listed a form from the "Permian(?)" of California as *Fusulinella* sp. that may represent it. With the exception of *Staffella texana* Harlton and *S. yobarensis* Ozawa, all of the species listed above, of which the horizons are definitely given, came from the Lower Pennsylvanian. In so far as I have been able to ascertain no other representatives of *Staffella* have so far been described.

In 1932, Liebus[18] described and illustrated a form from the Upper Mississippian of Germany which he referred to *Fusulinella struvii* Möller, the type specimens of which came from the Lower Carboniferous of Europe. This form is clearly distinct from *F. struvii* as originally illustrated and described by Möller but there is some question as to its generic affinities. The rounded periphery of its test and Liebus' description of its spirothecal structure suggest that this species is closely related to *Staffella*, but its very weak chomata are quite different from those of any known species of this genus. It possibly represents an unnamed genus distinct from and ancestral to *Staffella*.

From the description and illustrations of the genotype, the descriptions and illustrations of the species listed above, and all of the specimens available for study, I have drawn up the following generic diagnosis of *Staffella*.

Diagnosis of Staffella.—Shell small, spherical to ellipsoidal, typically slightly depressed in the axial regions (umbilicate). Axis of coiling the shortest diameter. Periphery broadly rounded. External furrows well defined. Mature forms consist of 4 to 10 volutions and are 0.30 mm. to 3.50 mm. in length and 0.45 mm. to 4.50 mm. in width. Form ratio 1:1 to 1:0.60. The spirotheca is composed of an upper and a lower tectorium, a tectum, and a diaphanotheca. The tectum and the diaphanotheca of the spirotheca are deflected downward to the base of the septa. The lower part of the diaphanotheca of the spirotheca of the succeeding chamber extends with decreasing thickness down the anterior side of the tectum apparently to the base of the septa. The anterior and posterior

[18] Liebus, A., Die Fauna des deutschen Unterkarbons, 3. Teil, Die Foraminiferen: *Preuss. Geol. Landesanstalt, Verhandl.*, N. F., Heft 141, p. 169, pl. 10, figs. 26–29, 1932.

sides of the septa are formed by tectoria. The tunnel is low and narrow and the tunnel angle is typically small. The line of intersection of the tunnel with axial sections is in general very irregular. The chomata of this genus are more strongly developed than are those of any of the fusulinids. They are usually over one-half the height of the chambers and extend from one-half to the entire distance from the tunnel to the poles. All of the generic characters which are here given are not clearly shown by Möller's illustrations or description of the cotypes of the genotype.

Representatives of *Staffella* may be distinguished from most genera of fusulinids by their short axis of coiling and their well developed chomata, and by the structure of the spirotheca. *Staffella* differs from *Nankinella* Lee in that it has a more broadly rounded periphery throughout growth, has much better developed chomata, has different spirotheca structure, and is smaller. In *Sphaerulina* Lee the spirotheca is composed of a tectum and keriotheca, the periphery of the inner volutions are more nearly angular than in *Staffella*, and the chomata are not as well developed as in *Staffella*. *Staffella* is so distinct from the spheroidal to subspheroidal Permian genera, such as *Eoverbeekina* and *Pisolina*, that detail comparisons seem unnecessary. *Staffella* may be distinguished from *Ozawainella* by its smaller form ratio and more broadly rounded periphery and by the difference in the development of the chomata.

STAFFELLA ATOKENSIS Thompson, n. sp.
Plate 13, figures 6–10

Shell minute, ellipsoidal. Periphery rather narrowly rounded for this genus. External furrows well defined. The general shape of the shell is rather uniform as it expands gradually, but its axial regions are somewhat depressed. Mature forms of five volutions are about 0.40 mm. in length and 0.63 mm. in width. The form ratio is about 1 : 0.65.

In the fourth volution near the tunnel the upper tectorium of the spirotheca is about 15.0 microns thick, the diaphanotheca is about 10.0 microns thick, and the lower tectorium is about 5.0 microns thick. These layers all thin rather rapidly poleward. The septal count gives 10 for the first volution, 14 for the second volution, and 16 for the third volution. The proloculum is spherical to ellipsoidal in shape and its inside diameter measures about 55 microns.

The tunnel is very narrow and the tunnel angle is about 17 degrees in the fourth volution and 20 degrees in the fifth volution. The chomata are well developed, they are about one-half the height of the chambers in the fourth volution, and they extend about two-thirds the distance to the poles.

Staffella atokensis more closely resembles *S. hollingsworthi* than any other described species, but it can be readily distinguished from that species as its proloculum is much smaller, its tunnel angle is smaller, its periphery is more narrowly rounded, it contains more volutions for mature forms of approximately the same size, and its form ratio is larger. *S. atokensis* can be distinguished from *S. keytei* by its weaker chomata, more narrowly rounded periphery, depressed axial regions (umbilication), and larger form ratio. It can be distinguished from *S. keytei maccoyensis* by its larger form ratio, more narrowly rounded periphery, more highly vaulted chambers, and its depressed axial regions.

This species resembles somewhat closely *S. mölleri* Ozawa, but the shell of that species at maturity is larger, it consists of a larger number of volutions, and it apparently has a larger tunnel angle. Also, the periphery of the American form is more narrowly rounded and the line of the tunnel is more irregular (compare Pl. 13, figs. 6–10 with fig. 18).

Galloway and Harlton[19] have described a form from the upper part of the Glenn

[19] Galloway, J. J., and Harlton, B. H., Some Pennsylvanian Foraminifera of Oklahoma, with special reference to the genus *Orobias: Jour. Paleontology*, vol. 2, p. 354, 1928.

(Hoxbar) formation of Oklahoma and referred it to *S. mölleri* Ozawa, and Galloway and Ryniker[20] have described a much smaller form from the lower portion of the Atoka of Oklahoma and referred it to *S. mölleri*. It seems to me very improbable that these American forms are conspecific with Ozawa's type specimens of *S. mölleri* which came from the Lower Pennsylvanian of Japan, but since Ozawa illustrated only an axial section (Pl. 13, fig. 18) and only external views and a sagittal section (all drawings) of the American forms have been published, satisfactory comparisons are not possible. However, *S. mölleri* of Galloway and Ryniker may be conspecific with the cotypes of *S. atokensis*, which came from about the same horizon and general locality.

Occurrence.—The cotypes of this species came from the lower part of the Atoka formation of Coal County, Oklahoma. They occur rather abundantly about 100 feet above the base of the formation in the center of the NW. ¼ sec. 10, T. 1 N., R. 8 E., (Pl. 13, figs. 6–10); very sparingly in a calcareous shale approximately 200 feet above the base of the formation in the center of sec. 2, T. 1 S., R. 8 E.; and at approximately the same horizon as the last in the center of the line of secs. 2 and 3, T. 1 S., R. 8 E., Coal County, Oklahoma.

Types.—Cotypes, Univ. Iowa nos. 825–833.

STAFFELLA KEYTEI MACCOYENSIS
Thompson, n. var.
Plate 13, figures 11–15

During a series of exchanges of collections with Mr. R. V. Hollingsworth I received a collection of fusulinids from the lower fossiliferous horizon of the McCoy formation at McCoy, Colorado (Roth, and Skinner's locality 174).[21] This collection was made by Mr. Phil Morey, of the University of Missouri, and I am very grateful to him for his permission to use them in this publication. The collection contains well preserved specimens of a small *Staffella* which differs considerably from *S. keytei* Roth and Skinner and which I am regarding as a new variety of that species.

Shell minute, subspherical, very slightly depressed to convex in the axial region. External furrows shallow. Periphery broadly rounded. The form ratio of mature individuals of six volutions is 1:0.80 to 1:0.90, and mature forms are 0.42 to 0.40 mm. in length and 0.54 to 0.55 mm. in width.

The septal count of the first five volutions of one of my specimens is 8 for the first volution, 13 for the second volution, 13 for the third volution, 18 for the fourth volution, and 20? for the fifth volution. The septa are slightly thicker than the spirotheca. All five of the layers of the septa are easily distinguished in some parts of several of the sections. The external furrows are straight throughout the length of the shell.

The diaphanotheca of the spirotheca is about 11 microns thick in the fourth volution and about 15 microns thick in the fifth volution. The wall of the proloculum is exceedingly thin, and the thicknesses for the different layers of the spirotheca in the line of the tunnel of the fourth volution are 7.5 microns for the upper tectorium, 11.1 microns for the diaphanotheca, and 5.6 microns for the lower tectorium.

The proloculum of this species is spherical to irregular in shape and its inside diameter measures about 50 microns. The first volution is very narrow and measures only about 95 microns. The tunnel is narrow and its intersection with axial sections is very irregular—in some specimens it varies as much as 30 degrees from a straight path. The tunnel angle is about 17 degrees in the sixth volution. The chomata are well developed and extend laterally almost to the axis of coil-

[20] Galloway, J. J., and Ryniker, Charles, Foraminifera from the Atoka formation of Oklahoma: *Okla. Geol. Survey, Circ.* 21, p. 22, 1930.

[21] Roth, Robert, and Skinner, John, The fauna of the McCoy formation, Pennsylvanian, of Colorado: *Jour. Paleontology*, vol. 4, p. 336, 1930.

ing. In the fifth volution the chomata are about one-half as high as the chambers.

The specimens which I am describing as a new variety of *S. keytei* agree in many respects with Roth and Skinner's description and illustrations of cotypes of the species. However, my specimens are slightly smaller, contain more volutions, have much more weakly developed chomata, and have a slightly different development of the inner volution than have the specimens described and illustrated by Roth and Skinner (compare Pl. 13, figs. 11–15 with figs. 16–17). In my opinion, the major difference between the new variety and the typical form is that the latter has chomata at least twice the size of the former. However, it is possible that Roth and Skinner's figured axial section has abnormally large chomata and that this is an individual and not a varietal difference.

It is very probable that representatives of this variety were included among the cotypes of *S. keytei*, for part of them came from the same horizon and locality as my specimens—the exact horizon and locality from which the figured cotypes of the species came is not given by Roth and Skinner.

Occurrence.—The above-described variety is only known to occur in the lower fossiliferous horizon of the McCoy formation at McCoy, Colorado.

Types.—Cotypes, Univ. Iowa nos. 834–839.

STAFFELLA HOLLINGSWORTHI
Thompson, n. sp.
Plate 13, figures 1–5

Shell minute, subspherical to ellipsoidal, slightly depressed in the axial region. External furrows well defined. Periphery broadly rounded. Mature specimens of four volutions are about 0.50 mm. in length and 0.60 mm. in width. The form ratio of mature forms is 1:0.70 to 1:0.83.

The septal count gives 11 for the first volution, 13 for the second volution, 15 for the third volution, and 21 for the fourth volution. The line of the external furrows is relatively straight from the depressed zone of the axis to the periphery, where it makes a broad shallow reëntrant. The proloculum is very large and its inside diameter measures 60 to 80 microns.

The wall of the proloculum is about 5 microns thick and the spirotheca is about 15 microns thick in the fourth volution where only the diaphanotheca and the tectum are developed. In the axial region the diaphanotheca is very thin and the spirotheca is covered on both sides by darker deposits of tectoria.

The tunnel is rather broad and its line of intersection with axial sections is very irregular. The tunnel angle measures 24 to 30 degrees. The chomata are well developed and they are about one-half the height of the chambers in the third volution and one-third the height of the chambers in the fourth volution. However, the chomata decrease in height rather rapidly poleward, and they are well developed for only about one-half the distance to the poles.

Staffella hollingsworthi resembles *S. atokensis* but the two species are easily distinguished; the tunnel angle of *S. hollingsworthi* is larger, its periphery is more broadly rounded, its proloculum is larger, and its form ratio is slightly smaller than that of *S. atokensis*. *S. hollingsworthi* can be distinguished from *S. keytei* by its larger proloculum, less well developed chomata, larger tunnel angle, and more depressed axial regions. *S. hollingsworthi* is larger for corresponding volutions, has fewer volutions at maturity, is more depressed in the axial regions, has a larger proloculum, and has a larger tunnel angle than *S. keytei maccoyensis*.

The form from the upper Glenn (Hoxbar) formation of Oklahoma that Galloway and Harlton[22] described as *S. mölleri* Ozawa may be conspecific with the cotypes of *S. hollingsworthi*.

[22] Galloway, J. J., and Harlton, B. H., Some Pennsylvanian Foraminifera of Oklahoma, with special reference to the genus *Orobias: Jour. Paleontology*, vol. 2, p. 354, 1928.

S. hollingsworthi resembles *S. mölleri* Ozawa from the Moscovian of Japan rather closely (compare Pl. 13, figs. 1–5 with fig. 18), but the two can be differentiated by the fact that in the American species there are fewer volutions, the shell is much smaller, and the general outline of the earlier volutions is different. Also, the chomata of the American species do not seem to be similar in cross-section to those of the Japanese species.

This species is named in honor of Mr. R. V. Hollingsworth who sent me all of the specimens on which this study is based.

Occurrence.—The cotypes of this species came from near the center of the NW. ¼ sec. 17, T. 2 N., R. 7 E., Pontotoc County, Oklahoma, in a brownish shale near the top of a hill, 300 feet south of Bois d'Arc Creek; this is the same as "Locality 93" of Morgan,[23] who regarded the shale outcropping there as upper Boggy.

Types.—Cotypes, Univ. Iowa nos. 840–845.

[23] Morgan, G. D., Geology of the Stonewall Quadrangle, Oklahoma: [*Oklahoma*] *Bureau of Geology, Bull.* 2, p. 241, 1924.

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UPPER EOCENE FORAMINIFERA FROM VENEZUELA[1]

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ABSTRACT

Fifty-four species and varieties of smaller foraminifera are identified, of which seven are new. These are *Clavulina venezuelana, Marginulina cocoaensis venezuelana, Gümbelina venezuelana, Discorbis mirandensis, Planulina venezuelana, Eponides bolivarensis,* and *Cibicides venezuelanus.* The fauna is derived from the upper part of the Pauji shale of late Eocene age, Venezuela. Its relationship with other American upper Eocene microfaunas is discussed.

The fauna here described was collected from the upper part of the series included by different writers under the name Pauji shale, which term has been employed to include a considerable thickness of strata. The lower part of the shale contains a different fauna from that of the upper part. In the region southeast of Lake Maracaibo the uppermost part of the Pauji shale is developed in a near-shore facies, to which the name Mene Grande series has been applied. The fauna of the Mene Grande series includes diagnostic species of larger foraminifera and an associated fauna of smaller foraminifera, a large number of which are also found in the underlying Pauji shale. The microfauna of the Mene Grande series and lower part of the Pauji shale is not described in this paper.

The smaller foraminifera of the upper part of the Pauji shale are of interest from the point of view of regional distribution since several species are present which have been recorded as typical of upper Eocene strata in other countries surrounding the Caribbean and Gulf of Mexico. Of particular significance is the occurrence of the following species.

Significant Species of Foraminifera from the Pauji Shale

Textularia martini Pijpers and *Planularia thalmanni* Pijpers, described from the upper Eocene of the Island of Bonaire, Dutch West Indies.

Chilostomella ovicula Nuttall from the upper Eocene of Trinidad.

Plectina dalmatina (Liebus), *Hantkenina* aff. *mexicana* Cushman, *Cristellaria mexicana* var. *nudicostata* Cushman and Hanna, and *Eponides mexicana* Cushman. These species are typical of the Eocene of the Tampico Embayment, Mexico, while the last two are also found in the Eocene of Texas.

Gyroidina danvillensis Howe and Wallace, recorded from the Jackson of Louisiana.

Siphonina advena var. *eocenica* Cushman and Ellisor from the Jackson of Texas.

There are several other species that occur elsewhere in America ranging through both Oligocene and Eocene strata.

[1] Published by permission of the Bataafsche Petroleum Maatschappij.

The Mene Grande series of the region southeast of Lake Maracaibo contains the following species of larger foraminifera,[2] which indicate its upper Eocene age.

Species of Larger Foraminifera from the Mene Grande Series

Discocyclina flintensis (Cushman)

Discocyclina blumenthali Gorter and Van der Vlerk

Asterocyclina maracaibensis Gorter and Van der Vlerk

Asterocyclina georgiana (Cushman)

Lepidocyclina (*Lepidocyclina*) *trinitatis* Douvillé

Lepidocyclina (*Lepidocyclina*) *pustolosa* Douvillé

Lepidocyclina (*Lepidocyclina*) *robert-douvillei* Lisson

Helicolepidina spiralis Tobler.

We conclude that there is no evidence for placing any of the Pauji series of the vicinity of the Maracaibo Basin in the Lower Oligocene, as proposed by Liddle.[3]

The writer is indebted to Miss Margaret Moore for the work in connection with the drawing of the specimens. Dr. J. A. Cushman has kindly given me valuable advice and enabled me to study comparative material from different areas. The figured specimens and paratypes have been placed in his collection.

SYSTEMATIC DESCRIPTIONS

Genus AMMODISCUS Reuss

AMMODISCUS INCERTUS (d'Orbigny)

Operculina incerta D'ORBIGNY, *1839*, in Sagra Hist. Phis. etc. Cuba. Foram., p. 49, pl. 6, figs. 16, 17.

Ammodiscus incertus BRADY, *1884*, Challenger Rept., p. 330, pl. 38, figs. 1–3.

Specimens show some variation in the width of the whorls and the number of coils.

Genus HAPLOPHRAGMOIDES Cushman

HAPLOPHRAGMOIDES EMACIATUM (Brady)

Plate 14, figure 1

Haplophragmium emaciatum BRADY, *1884*, Challenger Rept., p. 305, pl. 33, figs. 26–28.

Haplophragmoides emaciatum CUSHMAN, *1929*, Cushman Lab. Foram. Research, Contr., vol. 5, p. 78, pl. 12, fig. 3.

The test is compressed, the border lobate and the texture fairly coarsely arenaceous.

Genus AMMOBACULITES Cushman

AMMOBACULITES HUMBOLDTI (Reuss)

Plate 14, figure 2

Spirolina humboldti REUSS, *1851*, Zeitschr. deutsch. Geol. Ges., vol. 3, p. 65, pl. 3, figs. 17, 18.

Haplophragmium humboldti HANTKEN, *1875*, Mitt. a. d. Jahrb. k. ung. geol. Anstalt, vol. 4, p. 11, pl. 2, figs. 3, 4.—ANDREAE, *1884*, Geol. Specialkarte Elsass-Lothr., Abh., vol. 2, ser. 3, p. 198, pl. 7, fig. 2.

Test somewhat compressed, showing numerous chambers separated by depressed sutures. Early coiled portion very gently curved, small and indistinct, the major part of the shell being straight with four to six chambers. Aperture terminal, oval. Texture fairly coarsely arenaceous. Length 0.75 to 1.25 mm., width about 0.4 mm.

The specimens appear of rather coarser texture than the species figured from the European Oligocene; also the number of chambers in the uncoiled portion is usually greater.

Genus CYCLAMMINA Brady

CYCLAMMINA CANCELLATA Brady

Cyclammina cancellata BRADY, *1884*, Challenger Rept., p. 351, pl. 37, figs. 8–16.

This species is somewhat variable, but no differences of specific value have been observed in the specimens examined.

[2] Gorter, N. E., and Van der Vlerk, I. M., *Leidsche Geol. Mededeelingen*, vol. 4, pp. 97–99, 1932.

[3] Liddle, R. A., *The Geology of Venezuela and Trinidad*, pp. 242 and 244, 1928.

Genus TEXTULARIA Defrance

TEXTULARIA AGGLUTINANS d'Orbigny

Plate 14, figure 3

Textularia agglutinans D'ORBIGNY, *1839*, in Sagra Hist. Phis. etc. Cuba, Foram. p. 144, pl. 1, figs. 17, 18, 32–34.

The specimens assigned to this species are elongate and tapered and also show variation in the coarseness of texture of the test. Our specimens may be most closely compared with specimens figured by Cushman[4] from the Vicksburg of Mississippi and by Nuttall[5] from the lower Eocene of Mexico.

TEXTULARIA aff. PALA Czjzek

Plate 14, figure 4

Textularia pala CZJZEK, *1848*, Haidinger's Nat. Abh., vol. 2, p. 148, pl. 13, figs. 25–27.

Test broad, initial end acute, periphery narrow. Chambers very numerous, separated by oblique straight narrow sutures. Chamber surface flattened, texture fine. A broad band is sometimes present along the central longitudinal axis of the test, formed by the junction of the sutures.

TEXTULARIA MARTINI Pijpers

Plate 14, figure 5

Textularia martini PIJPERS, *1933*, Geol. Pal. Bonaire, p. 57, figs. 6–10.

Test short, tapered; initial end subacute. Chambers inflated, sutures much depressed and narrow. Texture fine, border lobate and broadly rounded. Aperture elongate. This species was described from the upper Eocene of the Island of Bonaire, Dutch West Indies.

Genus VULVULINA d'Orbigny

VULVULINA SPINOSA Cushman

Plate 14, figure 6

Vulvulina spinosa CUSHMAN, *1927*, Cushman, Lab. Foram. Research, Contr., vol. 3, p. 111, pl. 23, fig. 1; *1927*, Jour. Paleontology, vol. 1, p. 149, pl. 28, fig. 4.

Typical specimens of this species are frequent, this form also occurring in the lower Oligocene and upper Eocene of Mexico. The degree of development of the spines is somewhat variable.

Genus GAUDRYINA d'Orbigny

GAUDRYINA COLEI Nuttall

Plate 14, figure 7

Gaudryina colei NUTTALL, *1932*, Jour. Paleontology, vol. 6, p. 7, pl. 2, fig. 6.

Test cylindrical, gently tapered to a subacute initial end. Texture fairly fine. Sutures narrow, generally slightly depressed. Apertural face flattened; aperture a short arched opening at the base of the last formed chamber. This species occurs in the Tertiary of Trinidad and lower Oligocene of Mexico.

Genus DOROTHIA Plummer

DOROTHIA BRADYI Cushman

Gaudryina pupoides BRADY, *1884*, (not d'Orbigny, 1840), Challenger Rept., p. 378, pl. 46, figs. 1–4.

Gaudryina bradyi CUSHMAN, *1911*, U. S. Nat. Mus., vol. 71, pt. 2, p. 67, fig. 107.

Typical specimens of this species occur.

Genus PLECTINA Reuss

PLECTINA DALMATINA Liebus

Plate 14, figure 8

Gaudryina dalmatina LIEBUS, *1911*, Ak. Wiss. Wien, Sitz., vol. 120, p. 75, pl. 3, fig. 5.

Test short, initial end pointed, remainder of test with about four inflated chambers separated by wide depressed sutures. Texture fine to medium. Aperture circular or slightly arched situated near the center of the upper surface of the last chamber.

This species was described from the Eocene of Dalmatia and is also present in the Eocene of Mexico.

Genus CLAVULINA d'Orbigny

CLAVULINA VENEZUELANA Nuttall, n. sp.

Plate 14, figure 9

Test stout, with a short triserial part with numerous chambers, the last of which are inflated so that this part of the shell is the widest. Uniserial portion consisting of three to six chambers, which are wider than long with depressed sutures. Texture fairly fine. Average length 1 mm., diameter 0.3 mm.

[4] Cushman, J. A., *U. S. Geol. Survey, Prof. Paper* 129, p. 89, pl. 14, fig. 1, 1923.

[5] Nuttall, W. L. F., *Jour. Paleontology*, vol. 4, p. 279, pl. 23, fig. 5, 1930.

This species resembles *C. bramletti* Cushman,[6] from which it may be distinguished by having more chambers both in the triserial and uniserial portions.

Genus QUINQUELOCULINA d'Orbigny

QUINQUELOCULINA CF. LAMARCKIANA d'Orbigny

Plate 14, figure 10

Quinqueloculina lamarckiana D'ORBIGNY, *1839*, in Sagra Hist. Phis. etc. Cuba, Foram., p. 189, pl. 11, figs. 14, 15.

Test triangular, somewhat bulged at the center, border subacute. On the side, which shows four chambers, one stands out rather prominently. Surface smooth or sometimes showing very fine longitudinal striae. Aperture somewhat projected, circular, with a small tooth.

The form is less carinate than typical forms of this species.

Genus SPIROLOCULINA d'Orbigny

SPIROLOCULINA LIMBATA d'Orbigny

Plate 14, figure 11

Spiroloculina limbata CUSHMAN, *1929*, Cushman Lab. Foram. Research, Contr., vol. 5, p. 82, pl. 12, fig. 5.

The specimens assigned to this species are compressed with a rounded margin. The sutures are limbate, somewhat raised and the chamber surface which is flattened is slightly roughened.

Genus SIGMOILINA Schlumberger

SIGMOILINA CELATA (Costa)

Plate 14, figure 12

Spiroloculina celata COSTA, *1855*, Acc. Sci. Napoli, Mem., vol. 2, p. 126, pl. 1, fig. 14; *1856*, Acc. Pont. Atti., vol. 7, fas. 2, pl. 26, fig. 5.

The surface is roughened and no sutures are visible externally. The periphery is rounded and somewhat smoother than the remainder of the test. The aperture is extended and simple.

Genus CRISTELLARIA Lamarck

CRISTELLARIA KEMPERI Hanna

Cristellaria kemperi HANNA, *1923*, Calif. Univ., Pub. Geol. Sci., vol. 14, p. 323, pl. 59, fig. 1.—NUTTALL, *1932*, Jour. Paleontology, vol. 6, p. 10, pl. 1, fig. 8.

This species has a central boss, raised limbate sutures and narrow periphery. It is recorded from the lower Oligocene and Eocene of America.

CRISTELLARIA (SARACENARIA) ITALICA (Defrance)

Cristellaria italica BRADY, *1884*, Challenger Rept., p. 544, pl. 68, figs. 17, 18, 20–23.

The specimens are usually short, with rather few uncoiled chambers and a broad oval shape to the peripheral face of the last chamber.

CRISTELLARIA ROTULATA (Lamarck)

The forms assigned to this well known species have rather few chambers separated by nearly straight, narrow sutures and a sharp border.

CRISTELLARIA MEXICANA Cushman var. NUDICOSTATA Cushman and Hanna

Plate 14, figure 14

Cristellaria mexicana var *nudicostata* CUSHMAN and HANNA, *1927*, Calif. Acad. Sci., Proc., ser. 4, vol. 16, p. 216, pl. 14, fig. 2.

Test somewhat compressed usually with about the last two chambers uncoiled and the border acute. Sutures gently curved, thick and raised. The figured specimen is of an incompletely developed form.

CRISTELLARIA CULTRATA (Montfort)

Representatives of this well known species have a narrow peripheral keel.

Genus PLANULARIA Defrance

PLANULARIA THALMANNI Pijpers

Plate 14, figure 15

Cristellaria (*Planularia*) *thalmanni*, PIJPERS, *1933*, Geol. Pal. Bonaire, p. 60, figs. 27–29.

Test compressed, periphery rounded. Chambers of the earlier close-coiled portion small, becoming much larger and more elongate in the uncoiled portion. Specimens showing no uncoiled part are also present. The chamber surface is smooth, the sutures slightly elevated, increasing in width from the center towards the border. The terminal part of each suture near the periphery is gener-

[6] Cushman, J. A., *Cushman Lab. Foram. Research, Contr.*, vol. 5, p. 81, pl. 12, fig. 11, 1929.

ally somewhat raised and the large stellate aperture is partly visible through the test. Length up to 1.5 mm.

This species was described from the upper Eocene of the Island of Bonaire, Dutch West Indies.

Genus MARGINULINA d'Orbigny

MARGINULINA COCOAENSIS Cushman var. VENEZUELANA Nuttall, n. var.

Plate 14, figure 13

Marginulina cocoaensis CUSHMAN, *1925*, Cushman Lab. Foram. Research, Contr., vol. 1, p. 67, pl. 10, figs. 9, 10.

Test compressed, elongate with numerous prominent longitudinal costae, which partly obscure the individual chambers. This variety is very similar to the above species from the upper Eocene of Alabama and Texas. The Venezuelan specimens differ, however, in not possessing later inflated chambers, being compressed throughout in all forms examined.

MARGINULINA SUBBULLATA Hantken

Plate 14, figure 16

Marginulina subbullata HANTKEN, *1875*, K. Ungar. Geol. Anst., Jahrb., vol. 4, p. 46, pl. 4, figs. 9, 10; pl. 5, fig. 9.—CUSHMAN, *1925*, Cushman Lab. Foram. Research, Contr., vol. 1, p. 62, pl. 10, fig. 3.

Test composed of a few globular smooth chambers, separated by depressed sutures. Aperture terminal, stellate. This species is widely distributed in the Lower Tertiary of America.

MARGINULINA PEDIFORMIS Bornemann

Plate 14, figure 17

Marginulina pediformis BORNEMANN, *1855*, Deutsch. Geol. Ges., Zeitsch., vol. 7, p. 326, pl. 13, fig. 13.—COLE and PONTON, *1930*, Florida Geol. Survey, Bull. 5, p. 32, pl. 7, figs. 3, 4.

This species is rare.

Genus NODOSARIA Lamarck

NODOSARIA LONGISCATA d'Orbigny

Nodosaria longiscata D'ORBIGNY, *1846*, Foram. Foss. Vienne, p. 32, pl. 1, figs. 10–12.

Test smooth with very elongate chambers and narrow sutures. The specimens are usually broken, the inflated initial chambers being occasionally found.

NODOSARIA ADOLPHINA (d'Orbigny)

Dentalina adolphina D'ORBIGNY, *1846*, Foram. Foss. Vienne, p. 51, pl. 2, figs. 18–20.

Test small with globular chambers bearing spinose projections on their lower part. Sutures in much constricted necks. Aperture extended with a phialine lip.

Genus FRONDICULARIA Defrance

FRONDICULARIA TENUISSIMA Hantken

Plate 14, figure 21

Frondicularia tenuissima HANTKEN, *1875*, K. Ungar. Geol. Anst., Jahrb., vol. 4, p. 43, pl. 13, fig. 11.—CUSHMAN, *1927*, Cushman Lab. Foram. Research, Contr., vol. 3, p. 111, pl. 22, fig. 11.

Test small, oval, much compressed; initial end may be pointed. Chambers very numerous, narrow. This species occurs in the lower Oligocene and upper Eocene of Mexico.

Genus LAGENA Walker and Boys

LAGENA SULCATA (Walker and Boys)

Plate 14, figure 18

The forms assigned to this species have a subspherical chamber and the surface is covered with longitudinal costae. There is usually a short projecting neck of variable length, which towards its base has a narrow flange on either side continuing along the entire peripheral margin.

Genus NONION Montfort

NONION SCAPHA (Fichtel and Moll)

Plate 14, figure 19

Nonionina scapha BRADY, *1884*, Challenger Rept., p. 730, pl. 109, figs. 14, 15.

Test compressed, slightly elongate, border somewhat angled. Chambers numerous, not inflated; sutures narrow, depressed, gently curved.

Genus BOLIVINOPSIS Yakovlev[7]

BOLIVINOPSIS CLOTHO (Grzybowski)

Plate 14, figures 23, 24

Spiroplecta clotho GRZYBOWSKI, *1901*, Roz. Wydz. mat. przyr., vol. 41, p. 283, pl. 7, fig. 18.

Spiroplectoides clotho CUSHMAN, *1928*, Cushman Lab. Foram. Research, Contr., vol. 4, p. 101, pl. 14, figs. 13, 14.

[7] See Macfadyen, W. A., *Roy. Micros. Soc., Jour.*, vol. 53, p. 139, 1933.

Spiroplectoides (?) *clotho* CUSHMAN, *1934*, Cushman Lab. Foram. Research, Contr., vol. 10, p. 42, pl. 6, figs. 19–23.

Test elongate, slender, finely arenaceous. Chambers numerous. Microspheric form only observed.

This species has frequently been regarded as occurring only in the Upper Cretaceous of America. Forms indistinguishable from this species are found not infrequently in the Pauji series and also in the upper Eocene "Hantkenina zone" of Hospital Hill, Trinidad.

Genus GÜMBELINA Egger

GÜMBELINA VENEZUELANA Nuttall, n. sp.

Plate 15, figures 2–4

Test small, compressed, somewhat flattened, short; tapered to an acute initial end. Border rounded, lobate. Chambers inflated, smooth, separated by narrow, depressed sutures. Aperture an oval, arched opening, extending from the base of the last chamber for about one-third of the distance towards the periphery. The width of the aperture is less than

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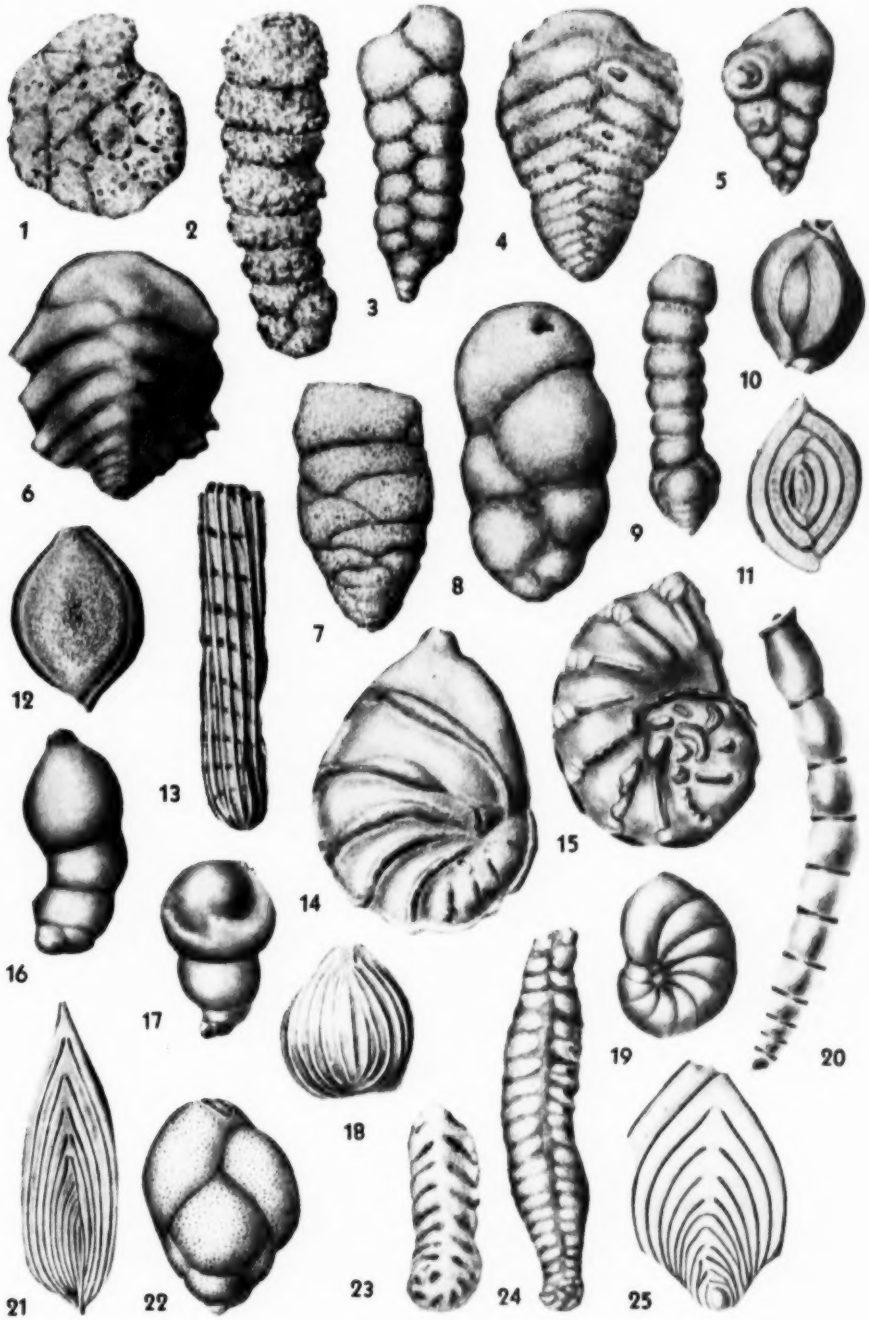
EXPLANATION OF PLATE 14

All specimens are from the upper Eocene Pauji shale, east and southeast of Lake Maracaibo, Venezuela.

FIG. 1—*Haplophragmoides emaciatum* (Brady), ×30. Cerro Caballo, Miranda district. (p. 122)
2—*Ammobaculites humboldti* (Reuss), ×30. Burro Negro, Bolivar district. (p. 122)
3—*Textularia agglutinans* d'Orbigny, ×30. Near Arnold Hill, Mene Grande, Sucre district. (p. 123)
4—*Textularia* aff. *pala* Czjzek, ×50. Near Arnold Hill, Mene Grande, Sucre district. (p. 123)
5—*Textularia martini* Pijpers, ×30. Near Arnold Hill, Mene Grande, Sucre district. (p. 123)
6—*Vulvulina spinosa* Cushman, ×30. Near Arnold Hill, Mene Grande, Sucre district. (p. 123)
7—*Gaudryina colei* Nuttall, ×30. Near Arnold Hill, Mene Grande, Sucre district. (p. 123)
8—*Plectina dalmatina* (Liebus), ×30. Near Arnold Hill, Mene Grande, Sucre district. (p. 123)
9—*Clavulina venezuelana* Nuttall, n. sp., ×30. Near Arnold Hill, Mene Grande, Sucre district. (p. 123)
10—*Quinqueloculina* cf. *lamarckiana* d'Orbigny, ×30. West of Cerro Gamelotal, northeast part of Bolivar district. (p. 124)
11—*Spiroloculina limbata* d'Orbigny, ×40. Cerro Caballo, Miranda district. (p. 124)
12—*Sigmoilina celata* (Costa), ×40. West of Cerro Gamelotal, northeast part of Bolivar district. (p. 124)
13—*Marginulina cocoaensis* Cushman var. *venezuelana*, n. var., ×30. Burro Negro, Bolivar district. (p. 125)
14—*Cristellaria mexicana* Cushman var. *nudicostata* Cushman and Hanna, ×40. Near Arnold Hill, Mene Grande, Sucre district. (p. 124)
15—*Planularia thalmanni* Pijpers, ×20. Cerro Caballo, Miranda district. (p. 124)
16—*Marginulina subbullata* Hantken, ×40. Near Arnold Hill, Mene Grande, Sucre district. (p. 125)
17—*Marginulina pediformis* Bornemann, ×40. Cerro Caballo, Miranda district. (p. 125)
18—*Lagena sulcata* (Walker and Boys), ×60. Near Arnold Hill, Mene Grande, Sucre district. (p. 125)
19—*Nonion scapha* (Fichtel and Moll), ×50. West of Cerro Gamelotal, northeast part of Bolivar district. (p. 125)
20—*Ellipsonodosaria verneuilii* (d'Orbigny), ×30. West of Cerro Gamelotal, northeast part of Bolivar district. (p. 127)
21—*Frondicularia tenuissima* Hantken, ×30. Near Arnold Hill, Mene Grande, Sucre district. (p. 125)
22—*Bulimina pupoides* d'Orbigny, ×60. Cerro Caballo, Miranda district. (p. 127)
23–24—*Bolivinopsis clotho* (Grzybowski), ×50. Near Arnold Hill, Mene Grande, Sucre district. (p. 125)
25—*Plectofrondicularia vaughani* Cushman, 30. Cerro Caballo, Miranda district. (p. 127)



Nuttall, Upper Eocene Foraminifera

the length. Average length 0.4 mm., width 0.4 mm.

This species resembles *Gümbelina globulosa* (Ehrenberg), which may be distinguished by being more inflated and having a different aperture.

It differs from *Gümbelina goodwini* Cushman[8] by being more inflated and possessing more chambers. Cushman[9] has previously mentioned the occurrence of *Gümbelina* in the upper Eocene of Venezuela and in the same paper he refers to other post-Cretaceous occurrences of *Gümbelina* in America. (See note, p. 131).

Genus PLECTOFRONDICULARIA Liebus

PLECTOFRONDICULARIA MEXICANA (Cushman)
Plate 15, figure 6

Frondicularia mexicana CUSHMAN, *1926*, Cushman Lab. Foram. Research, Contr., vol. 1, p. 88, pl. 13, fig. 5.
Plectofrondicularia mexicana NUTTALL, *1932*, Jour. Paleontology, vol. 6, p. 19.

Test elongate, narrow, compressed. Periphery with three flange-like keels. Chambers smooth, except usually only in the earlier part of shell which bears two or three longitudinal costae.

This species is frequent in the Oligocene and Eocene of Mexico and also is recorded from Trinidad. Both in specimens from Mexico and Venezuela the length of the longitudinal costae is variable. These costae are mentioned in Cushman's original description, but are not clear in his figure.

PLECTOFRONDICULARIA VAUGHANI Cushman
Plate 14, figure 25

Plectofrondicularia vaughani CUSHMAN, *1927*, Cushman Lab. Foram. Research, Contr., vol. 3, p. 112, pl. 23, fig. 3; *1927*, Jour. Paleontology, vol. 1, pl. 25, fig. 11; *1929*, Cushman Lab. Foram. Research, Contr., vol. 5, p. 92, pl. 13, figs. 21, 22.—CUSHMAN and JARVIS, *1930*, Jour. Paleontology, vol. 4, p. 361, pl. 33, fig. 4.

Test small, thin, much compressed, smooth. Sutures mostly regular, slightly depressed. This species has been recorded in beds of Miocene to upper Eocene age in Mexico, Trinidad, Venezuela and Ecuador. The forms assigned to this species by Cushman show variation in the degree of symmetry of the arrangements of the chambers.

Genus BULIMINA d'Orbigny

BULIMINA PUPOIDES d'Orbigny
Plate 14, figure 22

Bulimina pupoides D'ORBIGNY, *1846*, Foram. Foss. Vienne, p. 185, pl. 11, figs. 11, 12.—CUSHMAN, *1922*, U. S. Geol. Survey, Prof. Paper 129, p. 127, pl. 29, fig. 7.—NUTTALL, *1932*, Jour. Paleontology, vol. 6, p. 19, pl. 2, fig. 9.

The length of the test in this species is variable.

BULIMINA JACKSONENSIS Cushman
Plate 15, figure 1

Bulimina jacksonensis CUSHMAN, *1925*, Cushman Lab. Foram. Research, Contr., vol. 1, p. 6, pl. 1, figs. 6, 7.—CUSHMAN and APPLIN, *1926*, Am. Assoc. Petroleum Geologists, Bull., vol. 10, p. 168, pl. 7, fig. 8.—HOWE and WALLACE, *1932*, Louisiana Dept. Conserv., Geol. Bull. 2, p. 59, pl. 11, fig. 5.

Test stout, tapered to an acute initial end, with usually eight longitudinal costae which extend the whole length of the test. Average length 0.6 mm. This species is frequent in the upper Eocene of the Gulf Coast, U.S.A., and Mexico.

Genus UVIGERINA d'Orbigny

UVIGERINA aff. COCOAENSIS Cushman
Plate 15, figure 5

Uvigerina cocoaensis CUSHMAN, *1925*, Cushman Lab. Foram. Research, Contr., vol. 1, p. 68, pl. 10, fig. 12.

Test short stout, initial end pointed. Aperture extended to a tubular neck. Chambers with numerous fairly coarse costae. Last chamber usually smooth.

Genus ELLIPSONODOSARIA Silvestri

ELLIPSONODOSARIA VERNEUILII (d'Orbigny)
Plate 14, figure 20

Dentalina verneuilii D'ORBIGNY, *1846*, Foram. Foss. Vienne, p. 48, pl. 2, figs. 7, 8.
Ellipsonodosaria verneuilii CUSHMAN, *1930*, Jour. Paleontology, vol. 4, p. 364, pl. 33, fig. 12.

[8] Cushman, J. A., *Cushman Lab. Foram. Research, Contr.*, vol. 9, p. 69, pl. 7, figs. 15, 16, 1933.
[9] Cushman, J. A., *Op. cit.*, p. 65.

Test gently curved with numerous, distinct, smooth chambers, which become gradually larger and proportionately more elongate towards the aperture which is projecting with a phialine lip. The sutures are narrow and situated in constrictions between adjacent chambers, the last of which are more inflated than the earlier chambers. The initial end is pointed or with a short spine, the specimens found being mostly megalospheric.

Genus Discorbis Lamarck

Discorbis mirandensis Nuttall, n. sp.
Plate 15, figures 7–9

Test compressed, ventral surface usually somewhat more flattened than the dorsal, border rounded. Dorsally sutures gently curved, limbate raised or depressed. Ventrally sutures usually depressed in particular in the last chambers. Last chamber larger than preceding with extended lip over part of the umbilicus. Aperture arched extending from a short distance below the periphery towards the umbilicus. Average length 0.8 mm., thickness 0.3 mm. This species resembles *Discorbis araucana* (d'Orbigny), from which it differs in not being planoconvex and being more inflated.

Genus Gyroidina d'Orbigny

Gyroidina soldanii d'Orbigny

Gyroidina soldanii d'Orbigny, *1826*, Sci. Nat., Annales, vol. 7, p. 278, No. 5.—Cushman, *1929*, Cushman Lab. Foram. Research, Contr., vol. 5, p. 98, pl. 14, figs. 6, 7.

Test planoconvex with several visible whorls with numerous chambers, separated by gently curved sutures.

Gyroidina danvillensis Howe and Wallace
Plate 15, figures 10, 11

Gyroidina danvillensis Howe and Wallace, *1932*, Louisiana Dept. Conserv., Geol. Bull. 2, p. 69, pl. 13, fig. 3.

Test smooth, globular, biconvex, the dorsal side only slightly elevated. Border lobate, broadly rounded, dorsal surface with two whorls clearly visible. Ventrally

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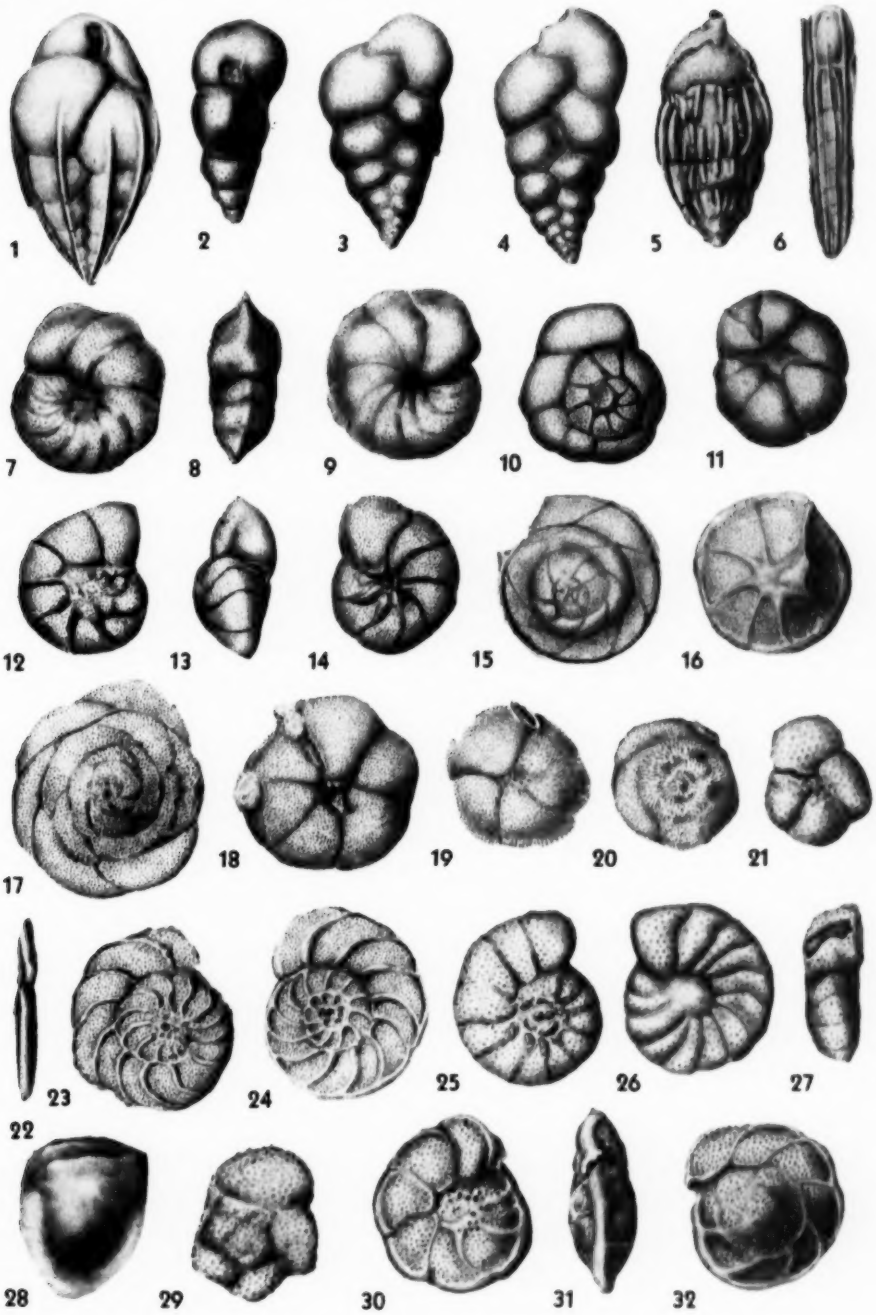
Explanation of Plate 15

All specimens are from the upper Eocene Pauji shale, east and southeast of Lake Maracaibo Venezuela.

Fig. 1—*Bulimina jacksonensis* Cushman, ×60. Cerro Caballo, Miranda district. (p. 127)
2, 3, 4—*Gumbelina venezuelana* Nuttall, n. sp., ×90. Pica Pica, Bolivar district. (p. 126)
5—*Uvigerina* aff. *cocoaensis* Cushman, ×50. Near Arnold Hill, Mene Grande, Sucre district. (p. 127)
6—*Plectofrondicularia mexicana* (Cushman), ×30. Cerro Caballo, Miranda district. (p. 127)
7–9—*Discorbis mirandensis* Nuttall, n. sp., ×30. 7, Dorsal view; 8, apertural view; 9, ventral view. Cerro Caballo, Miranda district. (p. 128)
10, 11—*Gyroidina danvillensis* Howe and Wallace, ×50. 10, Dorsal view; 11, ventral view. Burro Negro, Bolivar district. (p. 128)
12–14—*Eponides bolivarensis* Nuttall, n. sp., ×30. 12, Dorsal view; 13, apertural view; 14, ventral view. Burro Negro, Bolivar district. (p. 129)
15, 16—*Eponides mexicana* (Cushman), ×30. 15, Dorsal view; 16, ventral view. West of Cerro Gamelotal, northeast part of Bolivar district. (p. 129)
17, 18—*Eponides affinis* (Czjzek), ×30. 17. Dorsal view; 18, ventral view. Cerro Caballo, Miranda district. (p. 129)
19, 20—*Siphonina advena* Cushman var. *eocenica* Cushman and Ellisor, ×30. 19, Ventral view; 20, dorsal view. Cerro Caballo, Miranda district. (p. 129)
21, 29—*Globorotalia crassaformis* (Galloway and Wissler), ×40. 21, Ventral view; 29, dorsal view. Near Arnold Hill, Mene Grande, Sucre district. (p. 130)
22–24—*Planulina venezuelana* Nuttall, n. sp., ×30. 22, Apertural view; 23, ventral view; 24, dorsal view. Burro Negro, Bolivar district. (p. 130)
25–27—*Cibicides venezuelana* Nuttall, n. sp., ×50. 25, Ventral view; 26, dorsal view; 27, apertural view. Near Arnold Hill, Mene Grande, Sucre district. (p. 131)
28—*Allomorphina macrostoma* Karrer, ×60. Cerro Caballo, Miranda district. (p. 129)
30–32—*Cibicides ungeriana* (d'Orbigny), ×30. 30, Ventral view; 31, apertural view; 32, dorsal view. Near Arnold Hill, Mene Grande, Sucre district. (p. 131)



Nuttall, Upper Eocene Foraminifera

umbilicate, sutures depressed, chambers inflated, about six in the last coil. This species was described from the upper Eocene of Louisiana.

Genus EPONIDES Montfort

EPONIDES BOLIVARENSIS Nuttall, n. sp.
Plate 15, figures 12–14

Test approximately equally biconvex, rotaliform, finely perforate. Border usually rounded, but may be somewhat angled. Dorsally chambers indistinct, about two whorls visible. Sutures on both surfaces limbate, gently curved, slightly raised or flush with the chamber surface. The ventral surface has a central depression, which is irregularly partly filled with supplementary shell growth. About eight visible chambers on the ventral surface. Aperture a narrow, elongate slit at the base of the last chamber on the ventral surface. Average diameter 0.4 mm.

This species resembles *Eponides repanda* (Fichtel and Moll) which differs in having a more acute border and looser coiling visible on the dorsal surface.

EPONIDES MEXICANA (Cushman)
Plate 15, figures 15, 16

Pulvinulina mexicana CUSHMAN, *1925*, Am. Assoc. Petroleum Geologists, Bull., vol. 9, p. 300, pl. 7, figs. 7, 8.

Test biconvex, rotaliform, equally biconvex. Border subacute, finely perforate. Dorsal surface with thickened whorl lamina normally clearly visible with about two coils. Sutures narrow, nearly straight. Ventral surface with straight, somewhat thickened septa and about eight chambers. At the center a small circular depression, surrounded by a regular band of shell substance, formed at the convergence of the septa. Aperture a narrow slit extending about half the distance from below the periphery towards the umbilicus. Average diameter 0.6 mm.

This species is recorded from the Eocene of Mexico, Texas, and California.

EPONIDES UMBONATA (Reuss)

Rotalina umbonata REUSS, *1851*, Deutsch. Geol. Ges., Zeitschr., vol. 3, p. 75, pl. 5, fig. 35.

Eponides umbonata CUSHMAN, *1929*, Cushman Lab. Foram. Research, Contr., vol. 5, p. 98, pl. 14, fig. 8.

Test biconvex, central surface more elevated than the dorsal. Border narrow. Dorsally with several coils and nearly straight sutures. Ventrally with a curve at the inner end of the sutures.

This species has been recorded from various horizons in the Tertiary of Venezuela, Mexico and Ecuador.

EPONIDES AFFINIS (Czjzek)
Plate 15, figures 17, 18

Rotalina affinis CZJZEK, *1848*, Haidinger's Nat. Abh., vol. 2, p. 144, pl. 12, figs. 36–38.
Eponides affinis CUSHMAN and LAIMING, *1931*, Jour. Paleontology, vol. 5, p. 114, pl. 13, fig. 8.

Test equally biconvex, border angled. Both surfaces smooth, glossy, very finely perforate. Dorsally with early whorls somewhat obscure, in last coil the sutures are distinct, straight, oblique and narrow. Ventrally with six to seven visible chambers, separated by somewhat depressed, nearly straight, narrow sutures. At the center an umbilical depression.

Genus SIPHONINA Reuss

SIPHONINA ADVENA var. EOCENICA Cushman and Applin
Plate 15, figures 19, 20

Siphonina advena Cushman var. *eocenica* CUSHMAN and APPLIN, *1926*, Am. Assoc. Petroleum Geologists, Bull., vol. 10, p. 180, pl. 9, figs. 16–19.

Test biconvex with a narrow peripheral keel, fairly coarsely perforate. Sutures distinct. Aperture elliptical with a well developed neck with a broad lip.

The specimens appear to be identical with this species described for the upper Eocene of the Unites States Gulf Coast.

Genus ALLOMORPHINA Reuss

ALLOMORPHINA MACROSTOMA Karrer
Plate 15, figure 28

Allomorphina macrostoma KARRER, *1861*, K. Ak. Wiss. Wien, Sitz., vol. 44, p. 448, pl. 2, fig. 4.

Test oval, truncated at the apertural end, which may be straight or slightly oblique to the longer axis. Surface smooth,

glossy. Aperture an elongate slit extending across nearly the entire width of the broadest part of the test.

Genus CHILOSTOMELLA Reuss

CHILOSTOMELLA (CHILOSTOMELLOIDES) OVICULA Nuttall

Chilostomella (Chilostomelloides) ovicula NUTTALL, *1928*, Geol. Soc. London, Quart. Jour., vol. 84, p. 78, pl. 3, figs. 20, 21, text figure 2.

Test ovoid, aperture broad, crescentric, not standing out beyond the point of maximum thickness of the test. This species was described from Tertiary of Trinidad, where it is also present in the upper Eocene.

Genus GLOBIGERINA d'Orbigny

GLOBIGERINA INFLATA d'Orbigny

Globigerina inflata D'ORBIGNY, *1839*, Hist. Nat. Canaries Foram., p. 134, pl. 2, figs. 7–9.—BRADY, *1884*, Challenger Rept., p. 601, pl. 79, figs. 8–10.

Test plano-convex, dorsal side flattened, ventral elevated. Dorsally with several visible coils, the last chambers being higher than broad. Aperture crescentic, at the base of the last chamber.

This species, which is living, is common in the upper and middle Eocene of Mexico, the upper Eocene of Trinidad, and is recorded from the middle Eocene of Texas.

Genus GLOBOROTALIA Cushman

GLOBOROTALIA CRASSAFORMIS (Galloway and Wissler)

Plate 15, figures 21, 29

Pulvinulina crassa BRADY, *1884*, Challenger Rept., p. 694, pl. 103, figs. 11,12 (not *Rotalina crassa* d'Orbigny).

Globigerina crassaformis GALLOWAY and WISSLER, *1927*, Jour. Paleontology, vol. 1, p. 41, pl. 7, fig. 12.

Globorotalia crassula CUSHMAN and STEWART, *1930*, San Diego Nat. Hist., Trans., vol. 6, p. 77, pl. 7, fig. 1.—GALLOWAY and MOREY, *1931*, Jour. Paleontology, vol. 5, p. 342, pl. 38, fig. 12.

This species has a roughened exterior surface and possesses from four to five chambers in the last whorl.

Genus PLANULINA d'Orbigny

PLANULINA VENEZUELANA Nuttall, n. sp.

Plate 15, figures 22–24

Test compressed, nearly equilateral with the first coil on the ventral surface not visible. Sutures gently curved, usually thickened and elevated, except in some specimens where they may be depressed in the last chambers. Periphery narrow with a margin of clear shell substances. About twelve chambers in the last whorl, the chamber surface being flattened and coarsely perforate. Aperture narrow, peripheral. Average diameter 0.7 mm., thickness 0.1 mm.

This species resembles *Planulina mexicana* Cushman,[10] which differs in having more curved and less thickened sutures.

Genus HANTKENINA Cushman

HANTKENINA aff. MEXICANA Cushman

Hantkenina mexicana CUSHMAN, *1924*, U. S. Nat. Mus., Proc., vol. 66, art. 30, p. 3, pl. 2, fig. 2.

A single broken specimen of a form closely allied to this species was observed in our material. The occurrence of this genus in Venezuela is of interest, since it is frequent in the Eocene of Trinidad, Mexico, Cuba and the Gulf Coast of the United States.

Genus CIBICIDES Montfort

CIBICIDES TUXPAMENSIS Cole

Cibicides tuxpamensis COLE, *1928*, Bull. Am. Paleontology, vol. 14, No. 53, p. 19, pl. 1, figs. 2, 3; pl. 3, figs. 5, 6.—NUTTALL, *1930*, Jour. Paleontology, vol. 4, p. 291, pl. 25, figs. 2, 4.

Test biconvex, dorsal surface only slightly elevated, ventral surface much more convex. Both surfaces coarsely perforate. Dorsal surface with indistinct sutures. Border subacute. Ventral surface with fairly, strongly curved, slightly raised, limbate sutures of compact shell substance. Aperture a short arched opening over the periphery.

This species has a wide range in the

[10] Cushman, J. A., *Cushman Lab. Foram. Research, Contr.*, vol. 3, p. 113, pl. 23, fig. 5, 1927.

Mexican Tertiary from lower Oligocene to lower Eocene, where specimens appear identical with the Venezuelan forms.

CIBICIDES VENEZUELANA Nuttall, n. sp.
Plate 15, figures 25–27

Test planoconvex, coarsely perforate, dorsal surface flattened, ventral convex. On the dorsal surface the earlier whorls are obscured by shell growth, the sutures being either raised or depressed and gently curved. Ventrally sutures thick, limbate, elevated, chamber surface fairly coarsely perforate; about twelve chambers in the last whorl. At the center of the ventral surface some protruding shell growth, which consists usually of circularly arranged protuberances. Aperture a narrow arched slit extending over the periphery, which is subacute near the dorsal border. Average diameter 0.6 mm., thickness 0.2 mm.

Ventrally this species resembles *Anomalina cocoaensis* Cushman,[11] but is quite distinct dorsally.

CIBICIDES UNGERIANA d'Orbigny
Plate 15, figures 30–32

Test lenticular, equally biconvex, border usually lobate, subacute to rounded. Texture fairly coarsely perforate. Dorsally with earlier chambers obscured by shell growth; the last whorl with oblique sutures which may be depressed or level with the chamber surface. Ventral surface with about nine chambers, separated by gently curved sutures, which may be depressed or elevated. At the center of the ventral surface supplementary shell growth sometimes forming a boss. Aperture narrow, peripheral.

NOTE.—A new species of *Gümbelina* has recently been described from the upper eocene of Cuba (Palmer, D. K., *Soc. Cubana Hist. Nat., Mem.*, vol. 8, no. 2, p. 74, figs. 1–6, 1934).

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[11] Cushman, J. A., *Cushman Lab. Foram. Research, Contr.*, vol. 4, p. 76, pl. 10, fig. 1, 1928.

JOURNAL OF PALEONTOLOGY, VOL. 9, NO. 2, PP. 132–166, PLS. 16–18, MARCH, 1935

OSTRACODES OF THE UPPER PENNSYLVANIAN AND THE LOWER PERMIAN STRATA OF KANSAS: III. BAIRDIIDAE (CONCLUDED), CYTHERELLIDAE, CYPRIDINIDAE, ENTOMOCONCHIDAE, CYTHERIDAE AND CYPRIDAE

BETTY KELLETT*

ABSTRACT

Thirty-one species of ostracodes of the families Bairdiidae, Cytherellidae, Cypridinidae, Entomoconchidae, Cytheridae and Cypridae from Kansas are described, their observed ranges given, and all but one figured. Sixteen species are new.

Seventeen genera are described more or less at length, attention being paid to the hinge and marginal structures, muscle spots, and some other details of shell structure. Species referred to the genera *Bythocypris* Brady, *Sulcella* Coryell and Sample, and *Silenites* Coryell and Booth are especially interesting in respect to hinge and marginal structure.

Three of the described genera are new: *Coryellina* referred to the family Bairdiidae, *Basslerella* to the Cytheridae, and *Haworthina* referred doubtfully to the Cypridae. The genus *Basslerella* is regarded as ancestral to the Cretaceous genus *Cytheridea*. Following the conclusion of Geis, those Carboniferous forms referred respectively to *Cytherella* and *Cavellina* are regarded as congeneric, the supposed differences being attributed to sexual dimorphism. Since the Carboniferous forms further differ internally from *Cytherella* as represented by its Cretaceous genotype, they are held to constitute a separate genus for which the name *Cavellina* must be used. The first species of the genus *Cypridellina* to be noted in this country is described and figured. *Paraparchites*(?) *perminutus* Kellett is referred to the little known genus *Offa* Jones and Kirkby.

As in the preceding parts of this paper much emphasis is placed upon the ontogenetic series, differences between the young and the adult molts being noted within species of *Microcheilinella*, *Healdia*, *Cavellina*, *Sulcella*, *Silenites*, and *Monoceratina*. The changes taking place between the early and the late molts are especially striking in the genera *Sulcella* and *Cavellina*, both genera belonging to the Cytherellidae;—the earliest molts of one species of *Sulcella* differing from the adult in eight different ways.

An appendix contains a number of additions and corrections to previous papers dealing with Kansas ostracodes, and a graphic chart shows the range and abundance of all of the species of ostracodes which have as yet been described from outcropping Kansas strata.

This is the third and concluding part of a paper describing the ostracode faunas found in Kansas from the Stanton formation, Pennsylvanian, up into the Permian as far as the sedimentary conditions favored the occurrence of ostracodes. The preceding parts[1] should be referred to for the register of fossil localities' an explanation of methods, a consideration of variation within species, a list of the several museums where types are deposited, and for the acknowledgments.

Further acknowledgments should be made to those several other people

* Mrs. E. H. Nadeau, 510 West 6th Street, Topeka, Kansas.

[1] Kellett, B., Ostracodes of the Upper Pennsylvanian and the Lower Permian strata of Kansas: Part I, The Aparchitidae, Beyrichiidae, Glyptopleuridae, Kloedenellidae, Kirkbyidae, and Youngiellidae: *Jour. Paleontology*, vol. 7, no. 1, pp. 59–108, pls. 13–16, 1933; Part 2, The genus *Bairdia: idem*, vol. 8, no. 2, pp. 120–138, pls. 14–19, 1934.

to whom I am indebted for aid in preparing this last part. Without the explanation given in the yet unpublished work of Mr. H. L. Geis, I should perhaps have overlooked the true character of the cavellinid forms. Dr. J. H. Bonnema also helped in the solution of this difficult problem by his gift of sets of paired specimens showing the male and the female variations of various Cretaceous cytherellid species. Mr. Cecil G. Lalicker very carefully compared certain cavellinids with types at Harvard University. I also wish to acknowledge the courtesy in regard to loans of type specimens of Dr. Austin F. Rogers, Dr. Reginald W. Harris and Mr. W. R. Johnson. Dr. Ivan Alexander's careful study of the Cretaceous ostracodes made his cooperation most valuable in the study of the relationship of certain Carboniferous and Cretaceous genera.

FOSSIL LOCALITIES

In this paper and in the accompanying appendix an interesting ostracode fauna will be described which was found only recently and therefore not mentioned in the earlier parts of this paper. The fauna was made available through the kindness of Mr. Raymond A. Whortan of the T. C. Johnson Oil Company, Wichita, who collected it from a sandy phase of the Kanwaka shale, lower Shawnee group, Middle Pennsylvanian, along U.S. Highway 166, 3 miles west of Sedan, Chautauqua County, Kansas, in sec. 5, T. 34 S., R. 11 E. Beside the ostracodes many small gastropods were present in the fauna. This locality will be designated as Loc. 78.

Loc. 24 and Loc. 24A, described in part 1, have been definitely assigned to the Iatan limestone by Mr. Joseph M. Patterson of the University of Kansas, who has worked extensively on this part of the section.

SYSTEMATIC DESCRIPTIONS

Family BAIRDIIDAE G. O. Sars, 1887

Genus BAIRDIA M'Coy, 1844

The genus *Bairdia* and a number of species were described in the preceding part of this paper.

BAIRDIA GLENNENSIS Harlton

Plate 18, figures 4*a–e*

Bairdia glennensis HARLTON, *1927*, Jour. Paleontology, vol. 1, p. 210, pl. 33, fig. 10 (holotype examined). Upper Glenn formation, Carter County, Oklahoma; location corrected by Harlton (verbal communication) to the NE.¼, SE.¼, sec. 7, T. 5 S., R. 1 E.—(?) KNIGHT, *1928*, Jour. Paleontology, vol. 2, pl. 43, figs. 8*a*, *b*. Pawnee limestone, Missouri. Knight's identification was probably correct but his type is so weathered as to make positive identification uncertain.

Carapace very elongate for the genus, large; in lateral view dorsum and venter almost parallel; dorsum long and straight, venter long and almost straight, slightly concave at the center; anterior end evenly rounded; posterior beak low, bluntly rounded in the adult and rather pointed in the young specimens; outline in dorsal view narrow lanceolate; overlap narrow and rather even in the young, slightly more prominent dorsally in the adult specimens. Measurements of the figured specimens: fig. 4*a*, length 1.67 mm., height 0.70 mm.; figs. 4*c*, *d*, length 1.23 mm., height 0.51 mm., width 0.41 mm.; and fig. 4*e*, length 1.15 mm., height 0.43 mm.

The young specimens are not only more acuminate posteriorly and have a narrower dorsal overlap but they are also relatively more elongate. Single valves were rare and the hinge structure of the left valve could not be determined but the smaller right valve was seen to be grooved along the straight hinge.

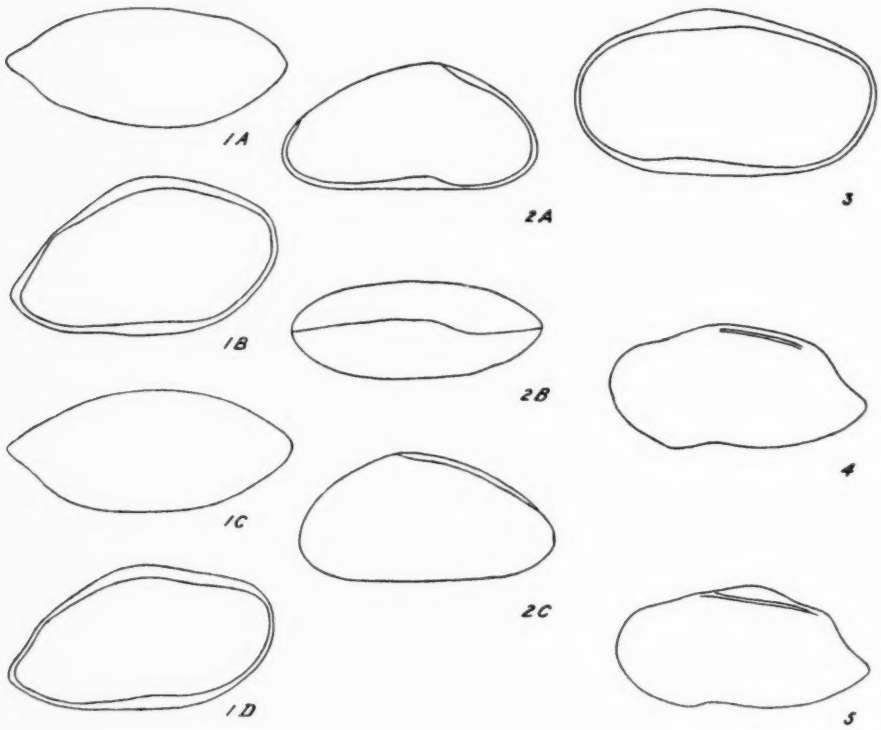
Lower Pennsylvanian to Permian. Stanton formation Loc. 22, two specimens. Elmdale formation, Loc. 60X, two

specimens; Loc. 64, seventeen specimens. Specimens have also been found in deep wells in central Kansas in the Tarkio and Burlingame formations. Plesiotypes, U. S. Nat. Mus. No. 90095.

BAIRDIA KANWAKENSIS Kellett, n. sp.
Text figures 1*a–d*

B. kanwakensis resembles closely some typical specimens of *B. oklahomaensis* Harlton[2] from the Seminole formation of Oklahoma with which this species was compared. However, in lateral view the

[2] *Bairdia oklahomaensis* Harlton, *Jour. Paleontology*, vol. 1, p. 209, pl. 33, fig. 7, 1927; upper Glenn formation, Oklahoma. *Texas Univ., Bull.* 2901, p. 156, pl. 3, figs. 5*a*, *b*, 1929; Graham formation, Menard County, Texas. Warthin, *Okla. Geol. Survey, Bull.* 53, p. 69, pl. 5, figs. 8*a*, *b*, 1930; Wewoka and



FIGS. 1*a–d*—*Bairdia kanwakensis* Kellett, n. sp. Right side carapaces with corresponding dorsal views above. Kanwaka shale, Loc. 78. Holotype, 1*a*, *b*. (p. 134)

2*a–c*—*Haworthina bulleta* (Harris and Lalicker). 2*a*, Right side carapace; 2*b*, dorsal view same carapace the anterior end to the right; 2*c*, left side same carapace. Grenola formation, Loc. 42. (p. 161)

3—*Cavellina marmorea* Kellett, n. sp. Left side carapace male, holotype. Kanwaka shale, Loc. 78. (p. 147)

4—*Bairdia folgeri* Kellett. Interior right valve with the hinge line indicated. Compare the straight dorsal outline above the hinge line of this species with the curved line of *B. whortani*, fig. 5. Howard formation, Loc. 25. (p. 135)

5—*Bairdia whortani* Kellett, n. sp. Interior right valve with the hinge line indicated. Kanwaka shale, Loc. 78. (p. 135)

All figures ×33 except 2*a–c*, which are ×54.

anterior is a little higher and narrower than that of *B. oklahomaensis*. The post-dorsal portion of *B. kanwakensis* is less inflated which gives a more tapering posterior in dorsal view. *B. kanwakensis* is also smaller. Measurements: length 1.04 mm., height 0.62 mm.; length 1.06 mm., height 0.67 mm.

Kanwaka shale, lower Shawnee group, Middle Pennsylvanian, Loc. 78, three specimens. Holotype and paratypes, U. S. Nat. Mus. No. 90096.

BAIRDIA WHORTANI Kellett, n. sp.
Text figure 5

B. whortani is very much like the lower Wabaunsee species *B. folgeri*.[3] The single but very distinguishing difference between this species and *B. folgeri* is the presence of a small protuberance on the dorsum of the smaller right valve of *B. whortani* just posterior to the center, caused evidently by a thickening of the shell. This protuberance extends above the hinge line leaving the hinge line on a closed carapace in a distinct depression. Text figures 4 and 5, which are camera-lucida drawings of the interiors of single left valves of *B. whortani* and *B. folgeri* with the hinge line indicated, show this difference in the post-dorsal region between the two species. Measurements: length 1.02 mm., height 0.60 mm.

Kanwaka shale, lower Shawnee group, Loc. 78, seven specimens. Holotype and paratype, U. S. Nat. Mus. No. 90097.

The name is in honor of Mr. Raymond A. Whortan of the T. C. Johnson Oil Company, Wichita, Kansas, who collected these specimens.

Genus BYTHOCYPRIS Brady, 1880

Bythocypris BRADY, *1880*, Challenger Rept., Zool., vol. 1, p. 45.—ULRICH and BASSLER, *1923*, Maryland Geol. Survey, Silurian, p. 320.

The following description is given by Ulrich and Bassler:

Shell smooth, reniform, ovate or elliptical; left valve larger than the right, overlapping it usually on both the dorsal and ventral margins; dorsal margin convex, the ventral edge straighter, sometimes slightly concave.

Genotype:[4] *Bythocypris reniformis* Brady, Recent. Range, Ordovician to Recent.

Marginal grooves, described below, have been found on the interior of the larger left valve of *B. pediformis* Knight, and of *B. osagensis* Kellett, n. sp.

BYTHOCYPRIS PEDIFORMIS Knight
Plate 16, figures 8*a–f*

Bythocypris pediformis KNIGHT, *1928*, Jour. Paleontology, vol. 2, p. 326, pl. 44, figs. 3*a–c;* lower Marmaton, Missouri.—WARTHIN, *1930*, Okla. Geol. Survey, Bull. 53, p. 74, pl. 6, figs. 6*a, b;* Wetumka to Holdenville formations, Oklahoma.—CORYELL and OSORIO, *1932*, Am. Midland Nat., vol. 13, p. 35, Marmaton, Oklahoma.—CORYELL and SAMPLE, *1932*, Am. Midland Nat., vol. 13, p. 267, pl. 25, fig. 18; Mineral Wells shale, Texas.—CORYELL and BOOTH, *1933*, Am. Midland Nat., vol. 14, p. 266, pl. 4, fig. 5; Wayland shale, Graham formation, Texas.—WILSON, *1933*, Jour. Paleontology, vol. 7, p. 419; McAlester shale, Oklahoma.

Bythocypris parallela KNIGHT, *1928*, Jour. Paleontology, vol. 2, p. 327, pl. 44, figs. 2*a, b;* lower Marmaton, Missouri.—CORYELL and SAMPLE, *1932*, Am. Midland, Nat., vol. 13, p. 25, fig. 11; upper Strawn Texas.

[4] Genotype citation taken on the authority of Ulrich and Bassler.

Holdenville formations, Oklahoma. Coryell and Billings, *Am. Midland Nat.*, vol. 13, p. 172, pl. 17, fig. 3, 1932; Wayland shale Graham formation, Texas. Coryell and Sample, *Am. Midland Nat.*, p. 264, pl. 25, fig. 9; East Mountain shale, upper Strawn group, Texas. *Bairdia auricula* Knight, *Jour. Paleontology*, vol. 2, p. 319, pl. 43, figs. 3*a, b*, 1928; Fort Scott limestone, Missouri. Warthin, *Okla. Geol. Survey, Bull.* 53, p. 68, pl. 5, figs. 7*a, b*, 1930; Wetumka and Wewoka formations, Oklahoma. Coryell and Osorio, *Am. Midland Nat.*, vol. 13, p. 34, 1932; Nowata shale, Marmaton group, Oklahoma. Coryell and Sample, *Am. Midland Nat.*, p. 263, pl. 25, fig. 6; East Mountain shale, upper Strawn group, Texas. Not *Bairdia dornickhillensis* Harlton, *Am. Jour. Sci.*, vol. 18, p. 268, pl. 2, figs. 12*a, b*, 1929; Dornick Hills formation, Oklahoma. *B. dornickhillensis*, which is found lower in the section than *B. oklahomaensis*, lacks the post-dorsal angulation of the later species.

[3] Kellett, B., *Jour. Paleontology*, vol. 8, no. 2, pp. 136–137, pl. 18, figs. 1*e–f*, 4*a–f*.

Bythocypris centralis CORYELL and BILLINGS, *1932*, Am. Midland Nat., vol. 13, p. 174, pl. 17, fig. 11; Wayland shale, Graham formation, Texas.—CORYELL and SAMPLE, *1932*, Am. Midland Nat., vol. 13, p. 265, pl. 25, fig. 12, Mineral Wells shale, Texas.

Bythocypris scapha CORYELL and BILLINGS, *1932*, Am. Midland Nat., vol. 13, p. 174, pl. 17, fig. 10; Wayland shale, Graham formation, Texas.

Bythocypris tomlinsoni CORYELL and BILLINGS (not HARLTON), *1932*, Am. Midland Nat., vol. 13, p. 175, pl. 17, fig. 9; Wayland shale, Texas.

Argilloecia subelliptica UPSON, *1933*, Neb. Geol. Survey, Bull. 8, (2) pp. 26–27, pl. 3, figs. 3*a–c;* uppermost Pennsylvanian and Lower Permian, Nebraska.

EXPLANATION OF PLATE 16

All figures ×30

FIGS. 1*a–l*—*Healdia compressa* Kellett, n. sp. Right sides carapaces with corresponding dorsal views above. All from the Howard formation, Loc. 25. Holotype, 1*a–b;* the rest are paratypes. Note compressed anterior end in dorsal view characteristic of this species, also variation in the length-height ratio between 1*a–e*. The smallest specimens, 1*j–l*, show short spines not developed on later molts. (p. 142)

2*a–e*—*Healdia simplex* Roundy. 2*a*, Left valve; 2*b*, interior of same valve, note marginal structure at post-dorsal angle and along dorsum; 2*c–d*, dorsal view and view right side carapace; 2*e*, right valve. All from the Stanton formation, Loc. 23. (p. 142)

3*a–c*—*Healdia parallela* Kellett, n. sp. 3*a*, Dorsal view and 3*b*, right side holotype; 3*c*, left valve paratype. Elmdale formation, Loc. 61. (p. 143)

4*a–b*—*Monoceratina lewisi* Harris and Lalicker. 4*a*, Ventral view carapace with the posterior end to the right; 4*b*, lateral view of a larger left valve. 4*a*, Wreford formation, Loc. 46; 4*b*, Grenola formation, Loc. 67. (p. 158)

5*a–d*—*Healdia winfieldensis* Upson, adult molts. 5*a*, *b*, Dorsal view and right side carapace; 5*c*, right side carapace; 5*d*, left valve. Elmdale formation, Loc. 64. (p. 143)

6*a*, *b*—*Healdia cuneata* Coryell and Billings. Dorsal view and right side carapace. Deer Creek formation, Loc. 18. (p. 143)

7*a–c*—*Coryellina firma* Kellett, n. sp. Holotype; 7*a*, dorsal view with anterior end to right; 7*b*, right side carapace; 7*c*, ventral view with the anterior end to the left. Note in fig. 7*c* the ventral depression near the posterior end which is characteristic of this genus. Howard formation, Loc. 25. (p. 138)

8*a–f*—*Bythocypris pediformis* Knight. 8*a–c* from the Howard formation, Loc. 25, and 8*d–f* from the Ft. Riley formation, Loc. 45. Note that the same variation in the length-height ratios occur at each of these widely separated horizons. 8*a*, *b*, *d*, and *e* are single left valves. 8*c*, *f* are the right sides of carapaces. (p. 135)

9*a–d*—*Carbonita* (?) *tumida* (Upson). 9*a*, *b*, lateral and ventral views of a right valve; 9*c*, *d*, dorsal view and left side carapace of another specimen. Grenola formation, Loc. 42. (p. 160)

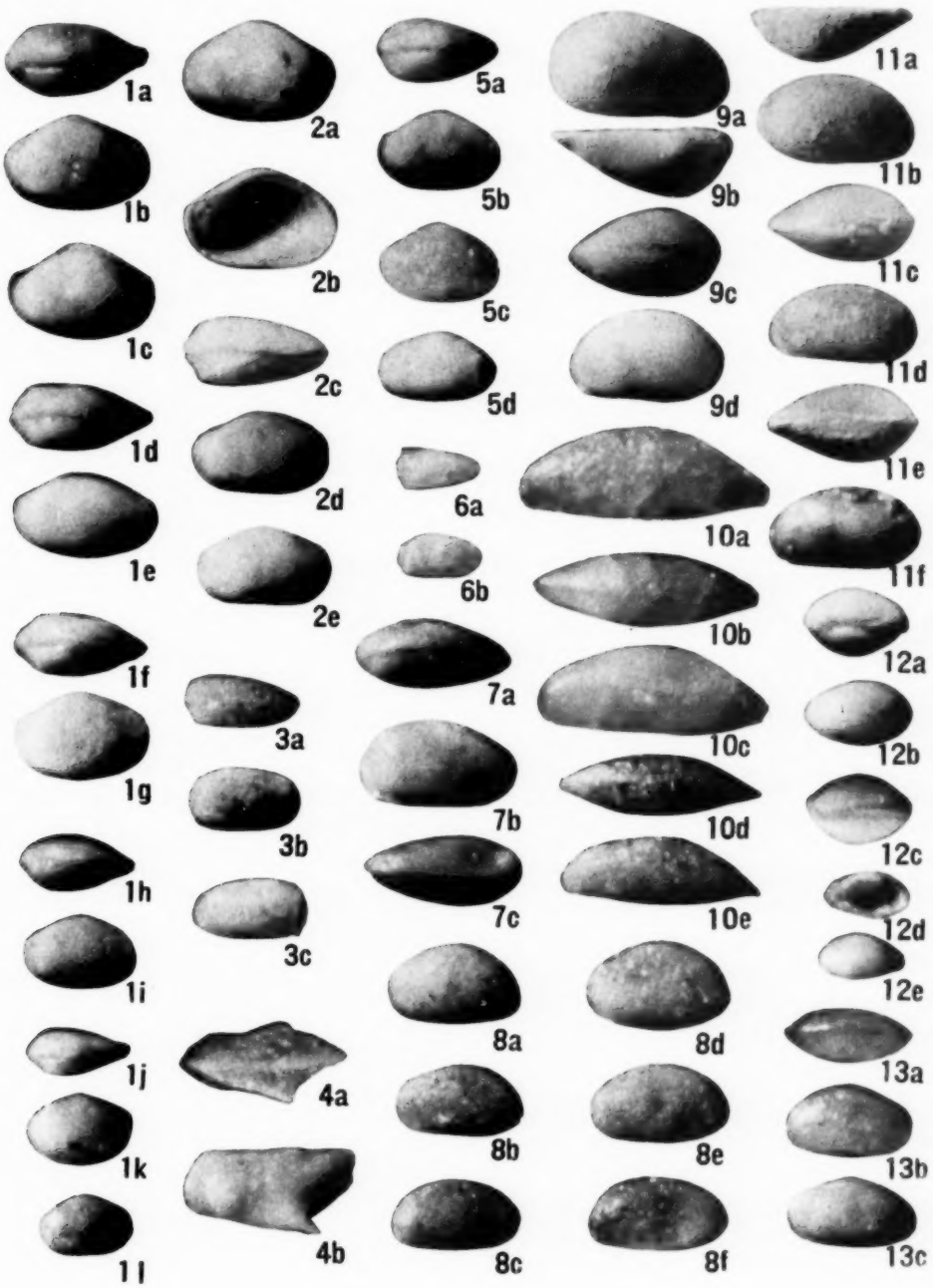
10*a–c*—*Macrocypris menardensis* Harlton. 10*a*, *c*, left sides carapaces; 10*b*, dorsal view of 10*c*. Right (posterior) end of 10*b*, *c*, broken off. Stanton formation, Loc. 22. (p. 138)

10*d–e*—*Macrocypris garrisonensis* Upson. Dorsal view and left side carapace of an adult molt. Elmdale formation, Loc. 60X. (p. 139)

11*a–f*—*Carbonita*(?) *tumida* var. *magna* (Upson) 11*a*, *b*, Dorsal and side views right valve; 11*c–e*, dorsal, left side and ventral views of a closed carapace, note the depressed hinge in 11*c* and the ventral overlap in 11*e*; 11*f*, left view showing circular muscle spot which can be seen in front of the center through the transparent valve. 11*a–e*, Howard formation, Loc. 25; 11*f*, Stanton formation, Loc. 22. (p. 161)

12*a–e*—*Microchilinella inflata* Kellett, n. sp. 12*a–c*, Dorsal, lateral, and ventral views of an adult carapace, holotype, anterior to the right in each case. 12*d–e*, Interior and exterior view of young left valve. Elmdale formation, Loc. 61. (p. 140)

13*a–c*—*Bythocypris osagensis* Kellett, n. sp. 13*a*, *b*, Dorsal view and right side carapace holotype; 13*c*, right valve paratype. Note the dorsal angulation when seen in lateral view characteristic of this species. Burlingame formation, Loc. 71. (p. 137)



Kellett, Pennsylvanian and Permian Ostracodes

Carapace subovate; greatest height a little behind the center or sometimes at or slightly in front of the center; dorsal margin very slightly to distinctly arched; ventral margin usually a little convex, sometimes slightly concave, anterior half a little narrower than the posterior in side view and broadly rounded; posterior margin slants roundly downward almost to the venter where it makes more or less of a right angle; greatest thickness posterior or posterior and central; left valve overlaps the right all around, most conspicuously at the venter and very little at the ends; the larger left valve has a groove extending along the interior of the entire dorsal margin and a ventral groove from the posterior angle almost to the anterior. Measurements of some of the figured specimens: fig. 8*d*, length 0.62 mm., height 0.39 mm.; fig. 8*e*, length 0.60 mm., height 0.33 mm.; fig. 8*f*, length 0.60 mm., height 0.31 mm.

Specimens showing the different variations in the convexity of the dorsal margin and the length-height ratio have been found to occur together consistently as noted by Warthin and Wilson, at numerous horizons from the Lower Pennsylvanian into the Permian. As Wilson notes these variations are probably due, in part at least, to sexual differences; however, it is apparently impossible to make a concise separation of the males and females because of the intergradation of the forms. *B. tomlinsoni* Harlton[5] also shows these variations at each horizon. This species, which is found lower in the section than *B. pediformis*, differs from it mainly in size, being about 0.15 mm. larger than the largest specimen of *B. pediformis* described. It is possible that *B. pediformis* is only a later and smaller development of *B. tomlinsoni*. Furthermore the Upper Pennsylvanian and Permian specimens of *B. pediformis*, although some attain a length of 0.63 mm., appear on the whole to be smaller than those from the Lower Pennsylvanian Marmaton group.

McAlester shale of Oklahoma, Lower Pennsylvanian, to Fort Riley limestone, Permian. Stanton formation: Loc. 21B, 2 specimens; Loc. 22, 6 specimens. Kanwaka shale, Loc. 78, 5 specimens. Deer Creek formation, Loc. 1, 4 specimens. Howard formation, Loc. 25, 30 specimens. Scranton shale, Loc. 30, 31 specimens. Burlingame formation Loc. 71, 7 specimens. Wakarusa limestone, Loc. 15, 1 specimen. Falls City (?) limestone, Loc. 40, 3 specimens. Elmdale formation: Loc. 60X, 15 specimens; Loc. 63, 1 specimen; Loc. 64, 1 specimen; Loc. 65, 5 specimens. Neva formation: Loc. 66, 1 specimen; Loc. 67, 10 specimens. Cottonwood limestone: Loc. 44, 2 specimens; Loc. 73, 12 specimens. Wreford formation: Loc. 43 ,1 specimen; Loc. 46, 1 specimen; Loc. 47, 4 specimens; Loc. 57, 7 specimens. Fort Riley limestone, Loc. 45, 124 specimens. Plesiotypes, U. S. Nat. Mus. Nos. 90098 (Loc. 25) and 90099 (Loc. 45).

BYTHOCYPRIS OSAGENSIS Kellett, n. sp.
Plate 16, figures 13*a–c*

This species is very much like *B. pediformis* Knight (Pl. 16, figs. 8*a–f*) but in lateral view the ends are more tapering and the dorsum angled or narrowly rounded at the center or just behind it, with rather straight dorsal margins sloping toward the ends on either side of the central angulation. The ventral interior marginal groove also differs from that of *B. pediformis*, instead of disappearing before reaching the antero-ventral portion of the valve it continues up the anterior margin half way to the hinge. Measurements of the figured specimens: figs. 13*a*, *b*, length 0.56 mm., height 0.31 mm., width 0.22 mm.; fig. 13*c*, length 0.56 mm., height 0.30 mm.

Burlingame formation, lower Wabaunsee group, Upper Pennsylvanian, Loc. 71, 3 specimens. Found also in the Burlingame formation in a deep well in central Kansas. Holotype and paratype, U. S. Nat. Mus., No. 90100.

[5] Harlton, B. H., *Am. Jour. Sci.*, vol. 18, p. 270, pl. 2, figs. 17*a–e*, 1929; *Jour. Paleontology*, vol. 7, pp. 25–26, pl. 7, fig. 9, 1933.

Genus CORYELLINA Kellett, new genus

Carapace subovate, dorsum arched, venter almost straight, ends rounded, greatest height and thickness slightly to the posterior; left valve overlaps the right all around; surface smooth except for a short, stout, blunt node near the post-ventral angle on the left valve with a depression in front of it.

Genotype: *Coryellina firma* Kellett, n. sp.; Howard limestone, lower Wabaunsee group, Upper Pennsylvanian.

Coryellina differs from *Bythocypris* Brady in the presence of the post-ventral short spine or node and depression. It differs from *Waylandella* Coryell and Billings[6] in having only one node on the carapace; furthermore this node is apparently not homologous with any of the spines of *Waylandella*, being shorter, blunter, nearer the post-ventral angle, and a more integral part of the valve than the post-ventral spine of *Waylandella*. *Waylandella* also lacks the depression in front of the post-ventral node characteristic of *Coryellina*.

The name is in honor of Dr. H. N. Coryell of Columbia University, who has described many ostracodes from the Mid-Continent region.

CORYELLINA FIRMA Kellett, n. sp.
Plate 16, figures 7*a–c*

Carapace subovate, dorsum moderately arched; venter straight; in lateral view anterior half narrower than the posterior; ends broadly rounded, the posterior end rather blunt; greatest height and thickness slightly to the posterior; carapace in dorsal view thick with the anterior end more pointed than the posterior; a short, stout, blunt spine or node present near the post-ventral angle on the larger left valve with a transverse depression in front of it slanting downward and forward; post-dorsal node seldom visible from the right side as it protrudes little beyond the edge of the carapace, no indication of a corresponding node on the right valve; surface smooth; left valve overlaps right all around, strongly at the venter, less at the ends and only slightly at the dorsum; the hinge structure could not be determined as no single valves found. Measurements of the figured specimen: length, 0.69 mm.; height, 0.39 mm.; width, 0.29 mm.

Upper Pennsylvanian. Deer Creek formation, middle Shawnee group, Loc. 1, 2 specimens. Howard formation, lower Wabaunsee group, Loc. 25, 3 specimens. Found also in the Howard formation in a deep well in central southern Kansas. Holotype, U. S. Nat. Mus. No. 90101.

Genus MACROCYPRIS Brady, 1867

Macrocypris BRADY, *1867*, Intellectual Observer, vol. 12, p. 119.—ULRICH and BASSLER, *1923*, Maryland Geol. Survey, Silurian vol., p. 321.—ALEXANDER, *1929*, Texas Univ., Bull. 2907, p. 59.

Carapace elongate, dorsum broadly arched and venter almost straight, in lateral view anterior rounded and posterior pointed, carapace in dorsal view elongate fusiform with tapering ends, right valve larger than the left and overlapping it or apparently overlapping it more or less completely all around, surface smooth.

Genotype,[7] *Macrocypris minna* Baird, a recent species. Range, Ordovician to Recent.

MACROCYPRIS MENARDENSIS Harlton
Plate 16, figures 10*a–c*

Macrocypris menardensis HARLTON, *1929*, Texas Univ., Bull. 2901, p. 161, pl. 4, figs. *7a, b;* Graham formation, lower Middle Pennsylvanian, Menard County, Texas. —DELO, *1930*, Jour. Paleontology, vol. 4, p. 174, pl. 13, fig. 10; deep well, Texas.—CORYELL and OSORIO, *1932*, Am. Midland Nat., vol. 13, p. 36; Nowata shale, Marmaton group, Lower Pennsylvanian, Oklahoma.

Carapace elongate; in lateral view dorsum broadly and evenly arched, ven-

[6] Coryell, H. N., and Billings, Gladys D., *Am. Midland Nat.*, vol. 13, p. 175, pl. 17, figs. 6–8, 1932; Coryell and Booth, *Am. Midland Nat.*, vol. 14, p. 268, pl. 5, fig. 5, 1933.

[7] Genotype citation taken on the authority of Ulrich and Bassler.

ter straight or slightly convex in the center and concave near the ends on either side of the central convexity, anterior extremity rather narrowly rounded, posterior extremity sharply pointed in both lateral and dorsal views and sometimes extended like the point of a pencil; overlap slight, easily discernible only on the antero-dorsal slope just anterior to the antero-dorsal angle and at the middle of the venter; overlap extremely narrow along the ends of the venter, the anterior of the carapace and the post-dorsal slope so that on small or weathered specimens it is apparently or actually absent; overlap entirely absent at the center and just anterior to the center of the dorsum and at the tip end of the posterior. Measurements of the figured specimens: length 1.16 mm., height 0.40 mm.; length 1.00 mm., height 0.39 mm., width 0.32 mm. The holotype of this species has a length of 1.14 mm. and the same height as this specimen.

The sharply pointed posterior ends have been broken from the specimens figured.

Lower and lower Middle Pennsylvanian strata. Stanton formation, Lansing group, Loc. 22, 2 specimens. One specimen found slightly below this horizon in a deep well in central Kansas. Plesiotypes, U. S. Nat. Mus. No. 90102.

MACROCYPRIS GARRISONENSIS Upson
Plate 16, figures 10*d–e*

Macrocypris garrisonensis UPSON, *1933*, Neb. Geol. Survey, (2), Bull. 8, pp. 25, 26, pl. 2, figs. 14*a–b*. Funston limestone, upper Garrison formation, Permian, Kansas.

M. garrisonensis differs only in its smaller size from *M. menardensis* and is undoubtedly a descendent of this earlier species. Measurements of the specimen from the Lower Permian figured in this paper are: length 0.89 mm., height 0.30 mm., and width 0.27 mm. These measurements are very close to those of the holotype. However, another specimen from the Permian is slightly larger, having a height of 0.35 mm.; the length could not be determined, the posterior end being broken from the carapace. The specimens of *M. garrisonensis* in the Upper and upper Middle Pennsylvanian are intermediate in size between the average small Permian forms and the larger adult specimens of *M. menardensis* of the lower Middle Pennsylvanian strata. It will be difficult in some cases to differentiate between these two species since they differ in size alone, and perhaps they should all be called *M. menardensis*.

Bairdia occidentalis Girty[8] from the Permian should evidently be *Macrocypris occidentalis* (Girty), new combination, judging from the type figure, and *M. garrisonensis* may be found to be the same species upon comparison of the holotypes. However *M. occidentalis* is apparently much larger.

Found from the Middle Pennsylvanian to the Wreford formation, Permian. Kanwaka shale, lower Shawnee group, Loc. 78, 1 specimen. Howard formation, deep well in central Kansas, 1 specimen. Burlingame formation in each of 2 deep wells, 1 specimen. Elmdale formation, Loc. 60X, 2 specimens; Loc. 64, 1 specimen. Neva limestone, Loc. 42, 1 specimen. Wreford formation, Loc. 43, 1 specimen; Loc. 57, 1 specimen. Plesiotype, U. S. Nat. Mus. No. 90103.

Genus MICROCHILINELLA Geis, 1933[9]

Microcheilus GEIS, *1932*, Jour. Paleontology, vol. 6, no. 2, pp. 149–188, pl. 25, figs. 15*a*, *b*, 17*a*, *b*.

Microcheilinella GEIS, *1933*, new name for *Microcheilus* preoccupied *1894*, Jour. Paleontology, vol. 7, no. 1, p. 112.

Carapace small and very tumid, width greater than the height; in lateral view oblong or ovate, ends rounded; maximum height median to anterior; dorsal view ovate, greatest thickness posterior to the center; maximum convexity at the middle or slightly above it in the right valve and below it in the left, so that, as Geis

[8] Girty, G. H., *U. S. Geol. Survey, Bull.* 389, pp. 41, 120, pl. 8, figs. 6, 6*a*, 1909.

[9] For the alteration in the spelling of this word see the International Rules of Zoological Nomenclature, *Biol. Soc. Washington, Proc.*, p. 90, 1926.

notes, "the end view has an obliquely compressed appearance"; left valve larger than the right and overlapping it along the free edges, overlap very strong in the antero-ventral portion; hinge short and straight, equalling half the length of the shell, and slightly to distinctly depressed; surface smooth or punctate.

Genotype by original designation, *Microcheilus distortus* Geis; Salem limestone, Mississippian, Indiana. Range of *Microchilinella*, Devonian (or Silurian?) to Lower Permian.

Single valves of only the Late Carboniferous species *M. inflata*, n. sp., have been examined. Each of these shows an even, fairly narrow border of calcareous inner lamella along the interior of the free edges. It is absent or very thin along the hinge. This border can be seen through the transparent valve in fig. 12*c*. The line of concrescence runs very close to the inner margin and perhaps coincides with it except at the ends.

MICROCHILINELLA INFLATA Kellett, n. sp.
Plate 16, figures 12*a–e*

M. inflata is much smaller and in lateral view more ovate than *M. distorta* (Geis)[10] or *M. subcorbuloides* (Jones and Kirkby),[11] and in dorsal view the greatest width is not so near the posterior although it is often more posterior than in the figured specimen of *M. inflata*. Furthermore the hinge of *M. inflata* is more depressed than that of *M. distorta*. The small specimen, figs. 12*d*, *e*, which is probably a neanic molt, is more narrowly rounded in lateral view at the ends, especially the posterior, than are the later molts. Measurements of the larger figured specimen: length 0.45 mm., height 0.29 mm., width 0.30 mm. A larger specimen from the same horizon had a length of 0.51 mm., and one from the Burlingame limestone a length of 0.53 mm.

[10] Geis, H. L., *Jour. Paleontology*, vol. 6, p. 181, 1932.

[11] Jones, T. R., and Kirkby, J. W., *Geol. Mag.*, Dec. 3, vol. 2, p. 540, 1885; *Ann. Mag. Nat. Hist.*, (5), vol. 18, p. 264, pl. 9, figs. 8*a*, *b*, 1886.

Middle Pennsylvanian to Lower Permian. Stanton limestone, Loc. 22B, 1 specimen(?) (somewhat mashed). Burlingame limestone, Loc. 71, 1 specimen. Falls City(?) limestone, Loc. 40, 5 specimens. Elmdale formation, Loc. 60X, 1 specimen; Loc. 61, 4 specimens; Loc. 64, 6 specimens. Holotype and paratype, U. S. Nat. Mus. No. 90104.

Genus ACRATIA Delo, 1930

Acratia DELO, *1930*, Jour. Paleontology, vol. 4, pp. 174, 175, pl. 13, figs. 12, 13.

Ends of the carapace pointed in both side and dorsal views, posterior end very low, anterior end high and often extremely attenuated, dorsum arched, venter straight, left valve larger than the right and overlapping it along the venter and the anterior third of the dorsum, surface smooth.

Genotype by original designation, *Acratia typica* Delo. Range of the genus, Lower or Middle Pennsylvanian to Permian.

Acratia is distinguished from the genus *Bairdianella* Harlton[12] by the considerably more pointed and drawn out anterior end of *Acratia* in side view. Harlton states that there is no dorsal overlap in the genus *Bairdianella*. However, I believe that material adhering to the holotype of *Bairdianella elegans*, genotype of *Bairdianella*, obscures a slight antero-dorsal overlap.

ACRATIA TYPICA Delo(?)
Plate 17, figures 3*a–d*

Acratia typica DELO, *1930*, Jour. Paleontology, vol. 4, p. 175, pl. 13, fig. 12. Upper Carboniferous, deep well, Texas.

Dorsum rounding evenly downward posteriorly almost to the venter, venter straight, extremities pointed in both side and dorsal views, posterior extremity very low and continuous with the straight venter; anterior extremity very much attenuated and curving slightly downward, at or above the mid-height of the valve, higher on the larger and more

[12] Harlton, B. H., *Texas Univ., Bull.* 2901, p. 160, pl. 4, figs. 5, 6, 1929.

nearly adult molts; width greater than the height; left valve overlaps the right along the anterior third of the dorsum and along the venter, overlap very prominent in the middle of the venter (see Delo's fig. 12*b*). Measurements of the figured specimens: length 0.73 mm., height 0.34 mm., width 0.36 mm.; length 0.88 mm., height 0.36 mm., width 0.38 mm. Other specimens not figured are larger, the largest having a length of 1.40 mm.

These specimens have a more attenuated anterior than the holotype, which has not been seen, but it is assumed that the slender anterior extremity is broken from the holotype.

The larger specimen figured here is slightly mashed and flattened dorsoventrally making the posterior extremity in dorsal view less acuminate than it would otherwise be. The largest specimens found have in dorsal view very narrow and pointed posterior ends. From the many carapaces of this species which are bent and contorted without being much broken it is probable that the shells of the living animal were rather thin and soft.

Lower Permian. Elmdale formation, Loc. 60X, 1 specimen; Loc. 63, 1 specimen; Loc. 64, 9 specimens. Neva formation, Loc. 42, 1 specimen. Plesiotypes, U. S. Nat. Mus. Nos. 90105 (Loc. 60X), 90106 (Loc. 42), and 90107 (Loc. 64, unfigured).

Family HEALDIIDAE Harlton, 1933

Genus HEALDIA Roundy, 1926

Healdia ROUNDY, *1926*, U. S. Geol. Survey, Prof. Paper 146, p. 8.

Carapace small; subtriangular to subelongate; dorsum arched, usually angular in the middle; venter almost straight; greatest height central or posterior; greatest thickness posterior; near the posterior of the valve the surface slopes abruptly toward the posterior, the line of greatest curvature often being ornamented with a vertical or crescentic ridge or with two backward pointing spines on each valve, one near the dorsum and the other near the venter; post-dorsal area somewhat flattened; carapace in dorsal view lanceolate; left valve larger than right and overlapping it except in the post-dorsal region; left valve grooved, except at the anterior, to receive the right; margin of right valve sometimes shows outer beveling along the dorsum and the anterodorsal portion; circular muscle scar central and only slightly depressed; inner calcareous lamella apparently not developed.

Genotype by original designation: *Healdia simplex* Roundy. Graham formation, Middle Pennsylvanian; Texas.

Range Missippian to Permian. Very common in the Lower Pennsylvanian and rather rare in the Permian.

There is a great variation in the length-height ratio of the specimens of each species of the genus *Healdia* (cf. Pl. 16, figs. 1*b* and 1*e*, 2*b* and 2*d*, and 5*c* and 5*d*).

Most of the Mississippian and Early Pennsylvanian species such as *H. ampla* Roundy,[13] with a length of 1.51 mm., and *H. caneyensis* Harlton,[14] with a length of 1 mm., are much larger than any found in the Middle Pennsylvanian; and the Permian species *H. winfieldensis* Upson, which has a maximum length of 0.52 mm., is quite small for the genus. The maximum development of the posterior ridges and spines is found also on the Mississippian and Early Pennsylvanian species. This tendency to ornamentation in the ancestral forms is reflected in the Upper Pennsylvanian species *H. compressa* Kellett, n. sp., (Pl. 16, figs. 1*a–l*) the early molts of which carry short spines which are absent on the latter molts. Several other of the later Pennsylvanian and Permian species show little or no ornamentation of the adults, and none show the very long spines such as seen on the Early Pennsylvanian spe-

[13] Roundy, P. V., *U. S. Geol. Survey, Prof. Paper* 146, p. 8, pl. 1, figs. 12*a*–13, 1926.

[14] Harlton, B. H., *Jour. Paleontology*, vol. 1, p. 208, pl. 33, figs. 2*a–c*, 1927; *Am. Jour. Sci.*, vol. 18, p. 261, pl. 1, figs. 9*a–e*, 1929; *Jour. Paleontology*, vol. 7, p. 26, pl. 7, fig. 10, 1933.

cies *H. overbrookensis* Harlton.[15] There thus seems to be in the genus *Healdia* a weakening of the ornamentation and a decrease in size with the passing of time.

HEALDIA SIMPLEX Roundy
Plate 16, figures 2*a–e*

Healdia simplex ROUNDY, *1926*, U. S. Geol. Survey, Prof. Paper 146, p. 8, pl. 1, figs. 11*a–c;* Graham formation, Middle Pennsylvanian, Texas.—CORYELL and BILLINGS, *1932*, Am. Midland Nat., vol. 13, p. 180, pl. 17, fig. 15; Wayland shale, Graham formation, Texas.—CORYELL and SAMPLE, *1932*, Am. Midland Nat., vol. 13, p. 268, pl. 26, fig. 1; East Mountain shale, upper Strawn, Texas.—CORYELL and BOOTH, *1933*, Am. Midland Nat., vol. 14, p. 267; Wayland shale, Texas.

Healdia absentia CORYELL and BILLINGS, *1932*, Am. Midland Nat., vol. 13, p. 179, pl. 17, fig. 13; Wayland shale, Texas.

Carapace medium sized for the genus, moderately thick, dorsal margin angled at the center, ventral margin straight or slightly concave, ends of about even height and broadly rounded, the post-dorsal slope flattened with the valves meeting evenly, spines on adult molts absent or only faintly indicated. Measurements of the figured specimens: figs. 2*a*, *b*, length 0.67 mm., height 0.43 mm.; figs. 2*c*, *d*, length 0.59 mm., height 0.35 mm., width 0.30 mm.

H. simplex and *H. compressa*, n. sp. have a groove along the interior margin of the left valve which can be easily seen at the center of the dorsum and at the post-dorsal angle (see Pl. 16, fig. 2*b*). It is absent at the anterior and along the post-ventral margin. The right valve is very distinctly beveled at the outer margin at the antero-dorsal angle, and the dorsum shows a slight beveling.

Middle Pennsylvanian. Stanton formation, Lansing group, Loc. 23, 75 specimens. Kanwaka shale, lower Shawnee group, Loc. 78, several specimens. Plesiotypes, U. S. Nat. Mus. No. 90108.

HEALDIA COMPRESSA Kellett, n. sp.
Plate 16, figures 1*a–l*

H. compressa resembles *H. simplex* very much in lateral view. However, they can be readily distinguished in dorsal view, the anterior portion of *H. simplex* being evenly convex, while the anterior of *H. compressa* is abruptly and narrowly constricted giving a pinched appearance to the anterior of the carapace. *H. compressa* is also slightly smaller than *H. simplex* and in lateral view is more convex ventrally and slightly more concave along the anterior of the dorsum. Measurements of some of the figured specimens are: figs. 1*a*, *b*, length 0.63 mm., height 0.42 mm., width 0.31 mm.; fig. 1*c*, length 0.63 mm., height 0.41 mm.; figs. 1*d*, *e*, length 0.63 mm., height 0.37 mm., width 0.28 mm.

Specimens of *H. compressa*, as well as those of most other species of this genus, vary a great deal in the ratio of the length to the height, with the shorter specimens having a somewhat more narrowly arched dorsum. The figured specimens 1*b* and 1*e* show this difference in lateral view, but the dorsal view of both specimens show the same very distinctive pinched-like anterior, proving that they are conspecific. Furthermore, specimens intergrading between these variations are found.

Another sort of variation is seen within *H. compressa* between the earlier molts which have short spines or nodes and the latest molts which lack these spines. The relationship between the two is shown, however, by the intergrading specimens and by the pinched anterior as seen in dorsal view of both the forms with spines and those without spines.

Upper Middle Pennsylvanian: Kanwaka shale, lower Shawnee group, to the Howard formation, lower Wabaunsee group. In the Kanwaka shale, Loc. 78, 42 specimens of *Healdia* occurred, part *H. compressa*, part *H. simplex* which is found lower in the section, and part specimens which in the degree of anterior compression seemed to be a link between these two species, perhaps indicating that *H. simplex* was the ancestor of *H. compressa*. Deer Creek formation, Loc. 18, 6 specimens. Howard formation, Loc. 25, 152 specimens; Bird Creek formation, the

[15] Harlton, B. H., *Jour. Paleontology*, vol. 1, p. 207, pl. 33, figs. 1*a–c*, 1927; *Am. Jour. Sci.*, p. 261, pl. 1, fig. 10, 1929.

equivalent of the Howard formation, cen. sec. 16, T. 27 N., R. 7 E., Oklahoma, Stop 11 of the Oklahoma City Geol. Soc. field trip, 1930, 19 specimens; also in the Happy Hollow and Howard limestones in two deep wells in central Kansas. Holotype and paratypes, U.S. Nat. Mus. No. 90109.

HEALDIA WINFIELDENSIS Upson
Plate 16, figures 5*a–d*

Healdia winfieldensis UPSON, *1933*, Neb. Geol. Survey (2), Bull. 8, p. 28, pl. 2, figs. 10*a–c*. Winfield formation, Nebraska.

Carapace small subtriangular, rather thick, dorsum angled at or just behind the center, venter straight or slightly convex, ends rounded and of almost equal height, post-dorsal area flattened, hinge line in post-dorsal area narrowly and slightly depressed, posterior spines absent or very short and inconspicuous, marginal structure like that of *H. simplex*. Measurements of the figured specimens which are of maximum size for the species: figs. 5*a*, *b*, length 0.52 mm., height 0.34 mm., width 0.28 mm.; fig. 5*d*, length 0.51 mm., height 0.30 mm.

H. winfieldensis is quite like *H. simplex* but it is decidedly smaller. *H. nucleolata* Knight[16] from the Lower Pennsylvanian lacks spines altogether and is not so thick or so arched dorsally as *H. winfieldensis*. *H. winfieldensis* is shorter than *H. ciscoensis* Harlton.[17]

Latest Pennsylvanian and Permian, upper Wabaunsee group to the Winfield formation. Falls City(?) limestone, Loc. 40, 2 specimens. Americus limestone, Loc. 70, 3 specimens. Elmdale formation, Loc. 60, 2 specimens; Loc. 60X, 7 specimens; Loc. 61, 1 specimen; Loc. 64, 11 specimens; Loc. 65, 2 specimens. Neva formation, Loc. 66, 1 specimen; Loc. 67, 9 specimens. Cottonwood limestone, Loc. 44, 11 specimens. Wreford formation, Loc. 43, 13 specimens; Loc. 57, 5 specimens; Loc. 68, 1 specimen. Winfield formation, Loc. 75, 14 specimens. Plesiotypes, U.S. Nat. Mus. No. 90110.

[16] Knight, J. B., *Jour. Paleontology*, vol. 2, p. 329, pl. 44, figs. 4*a–c*, 1928.

[17] Harlton, B. H., *Jour. Paleontology*, vol. 1, p. 202, pl. 33, figs. 4*a*, *b*, 1927; *Am. Jour. Sci.*, vol. 18, p. 265, pl. 2, fig. 6, 1929.

HEALDIA PARALLELA Kellett, n. sp.
Plate 16, figures 3*a–c*

Carapace small, elongate subrectangular, shell very thin, in dorsal view posterior abruptly truncated, in lateral view dorsum and venter almost parallel, dorsum slightly convex and venter stright, anterior rounded and slightly narrower than the posterior, posterior margin weakly convex, hinge line not depressed, near the posterior the surface of the valve curves abruptly downward to the posterior margin making an angle of curvature only slightly greater than a right angle, the crest of this escarpment ornamented by a thin, sharp ridge which reaches from the venter almost to the dorsum and has a slight forward convexity, no indication of spines present; interior groove on left valve developed all around the margin except at the anterior, most prominently developed along the posterior end of the dorsum, circular central muscle spot which is typical of the genus present. Measurements of the figured specimens: figs. 3*a*, *b*, length 0.50 mm., height 0.28 mm., width 0.22 mm.; fig. 3*c*, length 0.51 mm., height 0.26 mm.

Lowermost Permian, Americus limestone, Loc. 70, 1 specimen. Elmdale formation, Loc. 60, 2 specimens; Loc. 61, 5 specimens; Loc. 64, 1 specimen. Holotype and paratypes, U.S. Nat. Mus. No. 90111.

HEALDIA CUNEATA Coryell and Billings
Plate 16, figures 6*a*, *b*

Healdia cuneata CORYELL and BILLINGS, *1932*, Am. Midland Nat., vol. 13, p. 178, pl. 18, fig. 14. Wayland shale, Graham formation, Middle Pennsylvanian, Texas.

Carapace very small, subrectangular, dorsum slightly arched posterior to the center, venter straight, species characterized mainly by the abrupt posterior truncation of the carapace in dorsal view; a slight but very distinct vertical posterior ridge with a spine (in some cases?) occurring at the dorsal end of the ridge. Measurements of the specimens: un-

figured, length 0.37 mm., height 0.22 mm., width 0.185 mm.; figured, length 0.37 mm., height 0.20 mm., width 0.18 mm.

Only two specimens of this species were found; the one resembles almost exactly the holotype as shown by the original figure and has one dorsal spine on each valve as shown by Coryell and Billings. These spines are smaller and shorter than those figured. The other specimen, which is figured, is believed to be the same species although it lacks the spine because it has the peculiar posterior truncation of *H. cuneata*, the same sort of posterior ridge, and almost identical dorsal curvature. The lack of the dorsal spine on each valve and the slightly lower height of this specimen is here considered to be probably a matter of individual variation.

The dorsum of *H. cuneata* is more arched than that of *H. parallela* Kellett n. sp., and the posterior vertical ridge is more prominent. Furthermore, none of the specimens of *H. parallela* show any indication of spines.

Deer Creek formation, middle Shawnee group, Middle Pennsylvanian. Loc. 18, 2 specimens. Plesiotypes, U.S. Nat. Mus. No. 90112.

Family Cytherellidae G. O. Sars, 1865

Genus Cavellina Coryell, 1928, emend.

Cavellina Coryell, *1928*, Jour. Paleontology, vol. 2, p. 89.

Cytherella, the Carboniferous but not the post-Carboniferous species of authors.

The genus *Cytherella* was established first as a sub-genus by Jones[18] in 1849. A little later it was raised to generic rank by Bosquet.[19] Both of these authors studied Cretaceous material exclusively, and subsequently a Cretaceous species, *Cytherella ovata* (Roemer), the first species described and figured by Jones in 1849 as a *Cytherella*, was designated the genotype. *Cytherella* included those smooth, ovate or subovate species with a larger valve apparently overlapping a smaller one all around. Devonian to living species were included in this genus.

Coryell in 1928 established the genus *Cavellina* for a group of Pennsylvanian species of cytherellids which have a vertical ridge on the interior of the valve separating a depressed area in the posterior one-third of the body cavity from the rest of the cavity.

The literature on living ostracodes contains many references to the sexual dimorphism in *Cytherella* as reflected in the carapaces, but it was not until 1928 that students of the Cretaceous ostracodes noted the sexual dimorphism in Mesozoic Cytherellidae. They then pointed out[20] the male and female forms of many species of *Cytherella*, *Terquemia*, and *Cytherelloidea*, and showed that

> the carapace of the female is usually slightly larger than that of the male, and is proportionately higher and broader, especially near the posterior end. Within the space afforded by the inflated posterior region of the shell the eggs and the developing embryos are carried and protected.[21]

Van Veen, 1932, gives photographs of over twenty species of Cytherellidae comparing the interior of the valves of both the male and female of each species; and showing that the females have a vertical ventral ridge in the posterior half of each valve which is lacking on the valve of the male.

It is logical that since sexual dimorphism is strongly evident in *Cytherella* as far back as the Mesozoic it might well be expected in the earlier Carboniferous relatives of this genus. Geis has been working on this problem for some time

[18] Jones, T. R., Entomostraca of the Cretaceous of England, *Pal. Soc. London, Mon.*, p. 28, 1849.

[19] Bosquet, J., *Acad. Roy. Belgique, Mém. Courr.*, Brussels, vol. 24, p. 9, 1852.

[20] Van Veen, J. E., *Naturhist. Maand.*, vol. 17, no. 9, pp. 123–125, 1928. *Geologisch—Mijnbouwk. Genootschap Nederland Koloniën.* Verhandl., Geol. Ser, Deel 9, pp. 317–364, pls. 1–25, 1932. Alexander, C. I., *Am. Midland Nat.*, vol. 13, pp. 302–311, pl. 28, 1932

[21] Alexander, *idem*, p. 302.

and first demonstrated by his work[22] that the Carboniferous cavellinids are the females of the Carboniferous cytherellids, and that the cavellinids have the thickened, high posterior end and the posterior vertical ridge on the interior of the valve so typical of females of *Cytherella* from the Cretaceous to the present. Furthermore, when any number of cytherellids are found together there are always numerous cavellinids accompanying them. Geis notes—and this is borne out by my observation—that although there is always present in such an assemblage a series of young showing developmental stages leading up to the slender cytherellid form, only mature cavellinids are found, no single specimen that could be considered to lead up to the inflated cavellinid forms ever occurring. This fact that in many rich cavellinid-bearing samples there are never any young, while there are abundant young of the cytherellid forms accompanying them, can not easily be explained on any other ground than that the inflated specimens are the fertile females of the cytherellid forms.

The females of the cytherellid type in the Carboniferous all appear to have the posterior depression almost completely set off from the rest of the valve by a vertical ridge reaching from the venter almost or entirely to the dorsum. The ridges of the female *Cytherella* of the Mesozoic are in contrast much shorter, seldom reaching above the center of the valve, and consequently the posterior depressed portion of the valve is broadly connected dorsally with the rest of the valve (see the photographs by Van Veen, 1932). Because of the superior development of the posterior ridge and depression of the female of all Carboniferous species of the cytherellid type, it is believed that they deserve generic rank and should retain the generic name *Cavellina* to distinguish them from the typical *Cytherella* of the Cretaceous and later periods. It follows that all of the Carboniferous species which have been called *Cytherella* should be united with their respective female forms under the name of *Cavellina*.

Generic description.—Carapace oblong or ovate, dorsum moderately arched and venter slightly concave to convex; in lateral view the ends rounded, the postventral portion having a truncated appearance; posterior end thicker than the anterior, decidedly thicker in the female than the male; surface smooth; contact margin of the right (larger) valve grooved or rabbeted along its inner edge, to receive the smaller left valve which is sometimes beveled marginally; inner calcareous lamella lacking. Females sometimes shorter than the fully developed males, and thicker and higher, especially at the posterior; the females are also characterized by an internal depression in the posterior third of the valve, deepest ventrally, and set off from the rest of the valve by a more or less well developed vertical ridge reaching from the venter almost to the dorsum. This internal depression and ridge are only very faintly if at all developed in the male. Some young specimens show an external shallow pit over the central muscle spot, or an external vertical posterior ridge.

Genotype by original designation: *Cavellina pulchella* Coryell,[23] lower Middle Pennsylvanian, Oklahoma. *Cytherella gloria* Coryell and Sample[24] which occurs with it should be referred to *Cavellina pulchella* as the male form of the species. I believe that *Cytherella missouriensis* Knight,[25] *Cytherella wewokana* Warthin,[26] and *Cavellina lata* Coryell,[27] the type of which is a badly mashed and cracked specimen, are also synonyms of *C. pulchella*.

[22] Unpublished yet.

[23] Coryell, H. N., *Jour. Paleontology*, vol. 2, p. 94, pl. 11, fig. 5, 1928.

[24] Coryell, H. N., and Sample, C. H., *Am. Midland Nat.*, vol. 13, p. 271, pl. 26, fig. 14, 1932.

[25] Knight, J. B., *Jour. Paleontology*, vol. 2, p. 334, pl. 44, figs. 8*a–i*, 1928.

[26] Warthin, A. S., *Okla. Geol. Survey, Bull. 53*, p. 77, pl. 7, figs. 2*a*, *b*, 1930.

[27] Coryell, H. N., *Jour. Paleontology*, vol. 2, p. 94, pl. 11, fig. 11, 1928.

Range of *Cavellina:* Mississippian to Permian. The few pre-Carboniferous species called *Cytherella* may perhaps belong to the genus *Cavellina* or to the new and little known genus *Eocytherella* Bonnema.[28] Bonnema states that in this genus the interior of the shells of the female possess a simple posterior depression so that they stand out a little on the outside.

CAVELLINA NEBRASCENSIS (Geinitz), (new combination)
Plate 18, females, figures 1*a–e*, males, figures 1*f–h*

Cythere nebrascensis GEINITZ, *1866*, Carbonformation und Dyas in Nebraska: K. Leopold.-Carol. deutsch. Akad. Naturforscher, Verhandl., vol. 33, p. 2, pl. 1, fig. 2. Also published separately, 1866, at Nebraska City, Nebraska. The types came from Nebraska City from about the horizon of the Tarkio limestone, upper Wabaunsee group, Upper Pennsylvanian.

C. nebrascensis is a little smaller than *C. pulchella* Coryell, found lower in the Pennsylvanian strata, and is less arched dorsally in lateral view. The latter difference is particularly noticeable between the males of the species (the male of *C. pulchella* was formerly called *C. gloria*, cf. figs. 1*f–g*, Pl. 18) and the figures of the male of *C. pulchella* given by Coryell and Sample,[29] Warthin,[30] Delo,[31] and Jones, Kirkby and Brady.[32] *C. nebrascensis* is also smaller than *Cavellina ovoidiformis* (Harlton)[33] (new combination) found lower in the Pennsylvanian, the sides are more nearly parallel than shown in the type figures, the ends more narrowly rounded and the overlap less prominent than on *C. ovoidiformis*.

[28] Bonnema, J. H., *Zeitschrift für Geschiebeforschung*, vol. 9, no. 3, p. 6, 1933.
[29] Coryell, C. N., and Sample, C. H., *idem.*
[30] Warthin, Aldred S., *Okla. Geol. Survey, Bull. 53*, p. 78, pl. 7, figs. 1*a*, *b*, 1930.
[31] Delo, David, *Washington Univ. Studies*, n. ser., *Science and Tech.*, no. 5, p. 50, pl. fig. 10, 1931.
[32] Jones, T. R., Kirkby, J. W., and Brady, G. S., *Paleontogr. Soc., Mon.*, p. 78, pl. 7, figs. 7*a*, *b*, 1884.
[33] Harlton, B. H., *Jour. Paleontology*, vol. 2, p. 141, pl. 21, figs. 15*a*, *b*, 1928; *Texas Univ., Bull.* 2901, p. 161, pl. 4, figs. 8*a–c*, 1929.

The young of *C. nebrascensis* can be distinguished scarcely, if at all, from those of *C. fittsi* (see Pl. 18, figs. 2*f–3g*).

The females of *C. nebrascensis* show a low interior vertical ridge reaching almost to the dorsum with a deep depression behind it as is typical of the female of this genus. Measurements of the holotype (measured by Lalicker) and of the figured specimens:

Measurements of *Cavellina nebrascensis*

Figs.	Length	Height	Width
Holotype	0.91 mm.	0.54 mm.	0.39 mm.
1*a*, *b*	1.05 mm.	0.65 mm.	0.42 mm.
1*c*	1.10 mm.	0.65 mm.	
1*d*, e	1.07 mm.	0.62 mm.	0.43 mm
1*f*, *g*	1.17 mm.	0.65 mm.	0.37 mm

The types of *C. nebrascensis* were found by Dr. J. Brookes Knight at the Museum of Comparative Zoology, Harvard University, while examining the gastropod types of Geinitz. Later some Kansas *Cavellina* were sent to Mr. Cecil Lalicker, a graduate student there, who removed the holotype from a slab, cleaned it and identified some of the Kansas specimens as *C. nebrascensis*. The specimen figured in this paper (Pl. 18, fig. 1*c*) is described by Lalicker as "almost an exact image of the holotype." Mr. Lalicker made photographs and drawings of the holotype which he expects to publish.

Upper Pennsylvanian and Lower Permian; common from the Burlingame formation to the Neva formation, rare and doubtful specimens found in the Fort Riley limestone and the Winfield formation. Burlingame formation, Loc. 71, 1 specimen. Wakarusa limestone, Loc. 15, 9 specimens. Tarkio limestone, Loc. 32, 6 specimens. Falls City(?) limestone, Loc. 40, 33 specimens. Americus limestone, Loc. 70, 13 specimens. Elmdale formation, Loc. 60, 25 specimens; Loc. 60X, 33 specimens; Loc. 61, 3 specimens; Loc. 62, 19 specimens; Loc. 63, 2 specimens; Loc. 64, 100 specimens; Loc. 65, 168 specimens; Loc. 41A, 2 specimens. Neva formation, Loc. 67, 39 specimens; Loc. 42, 1 specimen. Fort Riley limestone, Loc. 45, left valve(?). Winfield formation, Loc. 56, 2 left valves(?).

Plesiotypes, U.S. Nat. Mus. Nos. 90113 (Loc. 64) and 90114 (Loc. 65).

CAVELLINA FITTSI Kellett, n. sp.
Plate 18, figures 2*a–e*, 2*f–3g* early molts

C. fittsi is distinguished by its large size and thick overlap. The female is larger, shorter, and has a thicker overlap than *C. nebrascensis*. The male form which is not figured is quite similar to that of *C. nebrascensis* (see Pl. 18, figs. 1*f*, *g*) except that it is larger and shorter. The dorsum of *C. fittsi* is less curved than that of *C. pulchella* Coryell.

The specimen shown in Pl. 18, figs. 2*f*, *g*, is the molt of a half grown specimen. Those in Pl. 18, figs. 2*a–g*, are the earliest molts of this species that have been found. They are relatively shorter and more wedge-shaped and blunt posteriorly in dorsal view than the adult molts. A short posterior vertical ridge is present on the smallest forms and the overlap is very slight. These young specimens are quite typical of many *Cavellina* and would probably be indistinguishable from the young of a number of other species of *Cavellina*.

Measurements of *Cavellina fittsi*

Figs.	Length	Height	Width
2*a*, *b*	1.10 mm.	0.70 mm.	0.49 mm.
2*c*	1.13 mm.	0.74 mm.	
2*d*, *e*	1.10 mm.	0.67 mm.	0.47 mm.

Upper Middle Pennsylvanian; Deer Creek formation to the Scranton shale. Deer Creek formation, Loc. 17, 1 specimen. Loc. 18, 13 specimens. Topeka formation Loc. 34, 1 specimen. Howard formation, Loc. 25, 229 specimens. Scranton shale, Loc. 30, 57 specimens. The specimens in the Deer Creek formation are not quite typical as they are a little smaller than those found in the Howard and the overlap is perhaps not so pronounced. U.S. Nat. Mus. No. 90115.

The name is in honor of Mr. John Fitts, geologist of Ada, Oklahoma.

CAVELLINA MARMOREA Kellett, n. sp.
Text figure 3, male

The female of *C. marmorea* differs very little from that of *C. fittsi* except that it is larger and the low and narrow ridge bordering the anterior of the left valve is more prominent. The male form is quite different from that of *C. fittsi*, however, for instead of being of equal height at each end, very slightly angled dorsally and with a rather narrow even dorsal overlap, the male of *C. marmorea* is much lower at the posterior than at the anterior end, is distinctly arched dorsally in front of the center, and has a prominent antero-dorsal overlap and a very slight post-dorsal overlap. Measurements: female, length 1.17 mm., height 0.75 mm; male, length 1.14 mm., height 0.71 mm.

Middle Pennsylvanian, Kanwaka shale, Loc. 78, 31 specimens, many of them young molts. Holotype and paratypes, U.S. Nat. Mus. No. 90116.

CAVELLINA EDMISTONAE (Harris and Lalicker)
Plate 18, figures 6*a–f*

Sansabelloides edmistoni HARRIS and LALICKER, *1932*, Am. Midland Nat., vol. 13, p. 402, pl. 37, fig. 5. Garrison shale formation, Permian, Kansas. Type examined.

Cavellina winfieldensis UPSON, *1933*, Neb. Geol. Survey, (2) Bull. 8, pp. 14, 15, pl. 2, figs. 8*a*, *b*. Gage shale, Permian, Nebraska. Type examined.

Cavellina subpulchella UPSON (not CORYELL), *1933*, Neb. Geol. Survey, (2) Bull. 8, pl. 2, figs. 7*a–c*. Eiss limestone, Permian, Nebraska. Type examined.

Cytherella ovata UPSON (not ROEMER), *1933*, Neb. Geol. Survey, (2), Bull. 8, pp. 15, 16, pl. 2, figs. 9*a–b*. Eiss limestone, Nebraska. Type examined.

Carapace very small for species of this genus, adults in lateral view rather short and the ends broadly rounded, dorsum slightly arched, venter straight to slightly convex; dorsal overlap narrow, widest at the anterior; posterior third of the interior of the female valves slightly depressed and set off by a low vertical ridge from the rest of the valve; females also show characteristic posterior inflation in dorsal view; the young and rare adults show a shallow central pit located just above the median line; surface smooth. Measurements of the figured specimens: figs. 6*a*, *b*, length 0.73 mm., height 0.42 mm., width 0.27 mm.; figs. 6*c*, *d*, length

0.71 mm., height 0.43 mm., width 0.29 mm.

In lateral view the young of *C. edmistonae* are narrower in the posterior than in the anterior half, the venter is slightly concave, and the overlap is very slight.

The holotype of *C. edmistonae* is a small and somewhat immature molt which still retains the central pit not found in the adults of this species. Such immature molts of *C. edmistonae*, many of a very small size, are common from the Elmdale to the Winfield formations. The central pit of the young probably indicates the descent of *C. edmistonae* from a *Sulcella*-like ancestor. The Nebraska specimen with the thickened posterior called *C. subpulchella* is evidently a mature female of *C. edmistonae*. It is only two-thirds as long as the type of *C. subpulchella* Coryell from the Lower Pennsylvanian. The specimen referred to *Cytherella ovata* (Roemer) by Upson lacks the angled dorsum of the Cretaceous species,[34] and is undoubtedly a male or immature female of *Cavellina edmistonae*. *C. edmistonae* is differentiated from most other Upper Carboniferous species by its small size, the only other species which is comparable in this respect is more elongate and occurs from the Boggy to the Belle City formation in Oklahoma.

Very rare in the Upper Pennsylvanian, and abundant in the Permian. Pennsylvanian: Burlingame limestone, Loc. 71, 1 specimen. Permian: Americus limestone, Loc. 70, 2 specimens. Elmdale formation, Loc. 60, 21 specimens; Loc. 60X, 6 specimens; Loc. 61, 7 specimens; Loc. 64, 7 specimens; Loc. 65, 2 specimens. Elmdale(?) formation, Loc. 41A, 5 specimens; Loc. 41, 31 specimens. Neva formation, Loc. 66, 3 specimens; Loc. 42, 142 specimens. Cottonwood limestone, Loc. 44, 10 specimens. Garrison formation, Loc. 59, 4 specimens. Wreford formation, Loc. 43, 26 specimens; Loc. 46, 71 specimens; Loc. 47, 52 specimens; Loc. 57, 1 specimen. Fort Riley formation, Loc. 45, 91 specimens. Winfield formation, Loc. 56, 247 specimens; Loc. 75, 14 specimens. Plesiotypes, U.S. Nat. Mus. Nos. 90117 (Loc. 42) and 90118 (Loc. 60).

[34] See Alexander, C. I., *Texas Univ., Bull.* 2907, p. 47, pl. 1, figs. 1–3, 1929.

CAVELLINA CHASENSIS Kellett, n. sp.
Plate 18, figures 5*a*, *b*

Carapace very small, elongate, greatest thickness central, greatest height central, ends of equal height in lateral view, dorsal margin obtusely angled at the center, ventral margin straight, posterior margin sloping forward, anterior margin broadly rounded, dorsal view elongate and spindleshaped, dorsal apparent overlap of right valve distinct and widest at the center, overlap around rest of valve extremely slight and barely perceptible. Measurements of the figured specimen: length 0.53 mm., height 0.27 mm., width 0.19 mm.

Wreford formation, Permian, Loc. 57, 1 specimen. Holotype, U.S. Nat. Mus. No. 90136.

Genus SULCELLA Coryell and Sample, 1932

Sulcella CORYELL and SAMPLE, *1932*, Am. Midland Nat., vol. 13, p. 275, pl. 26, figs. 17, 18.

Sansabelloides HARRIS and LALICKER, *1932*, Am. Midland Nat., vol. 13, p. 401, pl. 37, figs. 4*a*, *b*.

Carapace subrectangular to subovate; dorsum weakly arched and venter slightly concave to convex; in lateral view ends rounded, the post-ventral portion somewhat truncated; posterior end thickened and in dorsal view blunt; in lateral view a faint posterior vertical ridge sometimes present along the line of greatest thickness, a subcentral pit or sulcus a little above the center of the valve; an inconspicuous ridge or slight flange borders the anterior and the post-ventral margins of each valve but is best developed on the smaller left valve; right valve apparently overlapping the left all around, especially in the antero-dorsal region; hinge structure almost identical to that of *Cytherella*, consisting of a shelf-like beveling along

the margins of the right valve, most prominent in the antero-dorsal portion, into which fits the smaller left valve; left valve sometimes has a faint groove along the dorsum and the venter; females more inflated than the males.

Genotype by original designation: *Sulcella sulcata* Coryell and Sample, Lower Pennsylvanian, Texas.

The young of *Sulcella* differ from the adult forms in many other respects than size, and without a knowledge of the intervening stages, early and late molts of a single species might easily be assigned to different species. A study of an intergrading series of *S. sulcata* of progressive sizes from the same horizon and locality has shown that the earliest molts differ from the adults in the following respects:

Differences between Molts of Sulcella sulcata

(1) The earliest molts are relatively shorter than adult molts.

(2) The early molts are higher at the anterior than at the posterior, thus giving the venter a downward and forward swing, while the adults are of equal height at the ends.

(3) The earliest molts have a slightly concave venter, the medium sized molts a straight venter, and the latest molts a rather convex venter.

(4) In dorsal view the earliest molts are wedge-shaped, very thick at the posterior and very thin at the anterior; with age the anterior portion of the valve fills out a great deal.

(5) The earliest molts are a little more blunt posteriorly in dorsal view than the adults.

(6) The apparent overlap of the early molts is thin and inconspicuous, but becomes thicker with each molt until it is quite thick dorsally and ventrally in the final molts.

(7) The pit in the young is located slightly posterior to the center, later it is central, and in the adult slightly anterior to the center. This indicates a greater elongation of the posterior portion of the valve than of the anterior with age.

(8) The pit in the young is relatively larger and extends more nearly to the dorsum, resembling a sulcus rather than the pit of an adult.

The young of other genera of the Cytherellidae also show some of these characteristics. For instance, the young of *Cavellina fittsi*, n. sp. (see Pl. 18, figs. 3*a*–*g*) differ from the adult molts in being relatively shorter, more wedge-shaped and blunt posteriorly in dorsal view, and in having thinner overlapping edges. The posterior ridge shown in this series of young *Cytherella* is evidently homologous to the posterior ridge of *Sulcella* and of the Pennsylvanian genus *Birdsallela* Coryell and Booth,[35] and it is probably the heritage from an ancestor common to all three genera. *Birdsallela* differs from *Sulcella* only in the lack of a pit and from very young *Cytherella* only in its greater size and elongation. The common ancestor of these Cytherellidae very likely resembled the young of *Sulcella*, apparently the most primitive of these genera as it still retains a sulcus in the young, in having a very high anterior, an inflated posterior, a slight overlap and a dorsal sulcus. The Silurian Kloedenellidae, with their lack of a definite anterior cardinal angle, perhaps most nearly fill these specifications for an ancestor of the Cytherellidae. The antero-dorsal overlapping tooth of the Kloedenellidae possibly survives in the maximum apparent overlap in the antero-dorsal region of the Cytherellidae.

SULCELLA SULCATA Coryell and Sample

Sulcella sulcata CORYELL and SAMPLE, *1932*, Am. Midland Nat., vol. 13, p. 275, pl. 26, fig. 18. Mineral Wells shale, Texas. Type examined.

Jonesina texana HARLTON, WARTHIN (not HARLTON), *1930*, Okla. Geol. Survey, Bull. 53, p. 60, pl. 4, fig. 10. Wewoka formation, Oklahoma. Type examined.

Sulcella wartheni CORYELL and SAMPLE, *1932*, Am. Midland Nat., vol. 13, p. 275, pl. 26, fig. 17. Mineral Wells shale, Texas. Type examined.

Sansabelloides texana HARRIS and LALICKER, *1932*, Am. Midland Nat., vol. 13, p. 402, pl. 37, figs. 4*a*, *b*. Francis formation, Oklahoma. Type examined.

[35] Coryell, H. N., and Booth, R. T., *Am. Midland Nat.*, vol. 14, p. 271, pl. 5, figs. 6 and 7, 1933

S. sulcata and *S. wartheni*, which are found occurring together both at the type localities and in my collections from other horizons, are placed in the same species because it is believed that *S. wartheni* is merely a molt of a half-grown specimen of *S. sulcata*. It is only about half as large as *S. sulcata*, and has all of the characteristics of the young of this genus as listed in the generic discussion in this paper. The type figure of *S. wartheni* shows many of the characteristics of a young specimen of *Sulcella*, especially those listed as numbers 2, 3, 6, 7 and 8. The type of *S. sulcata*, on the other hand, shows the convex venter, thickened overlap, equal ends, and inconspicuous pit slightly anterior to the center characteristic of adult molts.

The name *S. texana* cannot be used for this species because the first specimen described was not named *texana* but was only misidentified as belonging to the species *Jonesina texana* Harlton. Assuming that it were named *Jonesina texana* Warthin, then it would be a homonym of *J. texana* Harlton, and therefore automatically rejected under Article 36 of the International Rules of Zoological Nomenclature which states that "rejected homonyms can never be used again—even when the species is placed in another genus."

Measurements of the largest and the smallest of the specimens found in the Kanwaka shale: length, 0.96 mm., height, 0.56 mm.; length, 0.45 mm., height, 0.27 mm.

Range, Lower to Middle Pennsylvanian. Eight specimens in the Kanwaka shale, Shawnee group, Middle Pennsylvanian, Kansas, at Loc. 78. Plesiotypes, U.S. Nat. Mus. No. 90119 (Loc. 78, unfigured).

Genus SILENITES Coryell and Booth, 1933

Silenites CORYELL and BOOTH, *1933*, Am. Midland Nat., vol. 14, no. 3, p. 265, pl. 4, figs. 1, 2.

Carapace subtriangular; in lateral view dorsal margin highly arched and sloping into the broadly rounded ends; venter weakly concave just anterior to the center; post-ventral outline more broadly rounded and truncate than the antero-ventral outline; greatest thickness at or just behind the center; apparent overlap of the left valve very conspicuous dorsally and more inconspicuous ventrally and at the ends, greatest at the hinge along the post-dorsal margin; the right valve shows a slight angulation in the post-dorsal region and at the center of the dorsum; carapace smooth and unornamented; edge of left valve distinctly grooved along the hinge (see Pl. 17, fig. 9*f*) to receive the right valve, groove most distinct in the post-dorsal area and at the center of the dorsum, a slight groove also present at the ends and at the venter; interior muscle spot immediately anterior to the center, a distinct, large, circular depression with a pattern of two parallel vertical rows of small, nearly horizontal ridges almost covering it (see Pl. 17, fig. 9*i*); muscle spot not visible on the exterior; calcareous inner lamellae either not developed or developed only as a very thin and inconspicuous layer along the ventral margins of the left valve; fine normal pores in the shell wall. Dorsal overlap relatively narrower and less conpicuous on the immature than on the mature molts.

Genotype by original designation: *Silenites silenus* Coryell and Booth, Graham formation, Pennsylvanian, Texas, a synonym of *Silenites lenticularis* (Knight), Marmaton group, Pennsylvanian, Missouri. Range, Mississippian to Permian. Species occurring as early as the Silurian and Devonian appear from figures to belong also to this genus.

Silenites is referred tentatively to the family Cytherellidae because of the character of the overlap, the hingement and the pinnate muscle spot pattern.

Silenites resembles closely in shape, overlap, and large circular muscle spot the Devonian *Bairdiocypris* Kegel,[36] sub-

[36] Kegel, Wilhelm, *Preuss. Geol. Land., Jahrb.* for 1931, vol. 52, p. 246, pl. 13.

genus of *Bythocypris*, but it lacks the posterior ventral sulcus of *Bairdiocypris* which is on the right valve close to and paralleling the ventral margin. *Bythocypris marginifera* Geis[37] from the Upper Mississippian evidently should be *Silenites marginiferus* (Geis) (new combination). *Bythocypris devonica* Ulrich[38] may belong to this genus, as well as *Bairdia phillipsiana* Jones and Holl[39] from the Silurian. (See note, p. 166).

SILENITES LENTICULARIS (Knight)

Plate 17, figures 9*a–i*

Carbonia(?) *lenticularis* KNIGHT, *1928*, Jour. Paleontology, vol. 2, p. 335, pl. 44, figs. 9*a*, *b*. Pawnee limestone, Marmaton, Missouri. Types examined.

Bythocypris sasakwaensis WARTHIN, *1930*, Okla. Geol. Survey, Bull. 53, p. 73, pl. 6, figs. 5*a–b*. Holdenville formation, Marmaton, Oklahoma. Type examined.

Bythocypris gallowayi CORYELL and OSORIO, *1932*, Am. Midland Nat., vol. 13, no. 2, p. 35, pl. 5, figs. 3. Nowata shale, Marmaton, Oklahoma. Type examined.

Silenites gallowayi (CORYELL and OSORIO), CORYELL and BOOTH, *1933*, Am. Midland Nat., vol. 14, no. 3, p. 265.

Bythocypris faba CORYELL and OSORIO, *1932*, Am. Midland Nat., vol. 13, no. 2, p. 36, pl. 5, fig. 4. Nowata shale, Marmaton, Oklahoma. Type examined.

Silenites faba (CORYELL and OSORIO), CORYELL and BOOTH, *1933*, Am. Midland Nat., vol. 14, no. 3, p. 265.

Silenites silenus CORYELL and BOOTH, *1933*, Am. Midland Nat., p. 265, pl. 4, figs. 1, 2. Wayland shale, Graham formation, Texas.

Measurements of *Silenites lenticularis:*

Figs.	Length	Height	Width
9*a*, *b*	1.20 mm.	0.66 mm.	0.41 mm.
9*d*, *e*	1.22 mm.	0.74 mm.	0.48 mm.
9*g*, *h*	1.21 mm.	0.78 mm.	0.53 mm.

The type of *S. lenticularis* figured by Knight is a very poor specimen, much weathered, and only half grown, but a cotype is a much larger and better specimen. Other even larger adult specimens found in topotype material are indistinguishable from those in the Permian of Kansas.

Collections of *S. lenticularis* from many horizons in the Pennsylvanian and Permian show that the specimens at any one horizon form an intergrading series from rather thin elongate forms to much stouter and higher forms. Extremes of this series are shown in Pl. 17, figs. 9*a–b* and 9*g–h*. The early molts, the smallest specimens found, are relatively shorter and higher than the mature molts. The specimen called *S. gallowayi* is small and relatively short and is thought to be an immature specimen of *S. lenticularis*.

S. marginiferus Geis from the Mississippian is more inflated and one-third larger than any specimens of the Pennsylvanian *S. lenticularis*.

Range, lower Marmaton group, Lower Pennsylvanian, to the basal Fort Riley limestone, Permian. This species seems to be quite common in the Elmdale formation in Kansas and the equivalent Foraker formation in Oklahoma. Stanton formation, Loc. 22, 1 specimen. Deer Creek formation, Loc. 17, 1 specimen. Burlingame formation, Loc. 71, 3 specimens, Americus limestone, Loc. 70, 18 specimens. Elmdale formation: Loc. 60, 17 specimens; Loc. 60X, 15 specimens; Loc. 61, 3 specimens; Loc. 63, 2 specimens; Loc. 64, 6 specimens. Wreford formation: Loc. 43, 3 specimens; Loc. 57, 1 specimen. Shale in top Florence flint, Loc. 77, 1 specimen; shale in the very base of the Fort Riley limestone, quarry east of Florence, Marion County, Kansas, sec. 5, T. 21 S., R. 5 E., 1 specimen. *S. lenticularis* has been found in the deep wells of central Kansas no higher than the Florence flint. Plesiotypes, U.S. Nat. Mus. No. 90120 (Loc. 60) and 90121 (Loc. 70).

Family CYPRIDINIDAE Baird, 1850

Genus CYPRIDINA Milne-Edwards, 1837

Cypridina MILNE-EDWARDS, *1837*, Hist. Nat. Crust., vol. 3, p. 409, pl. 36, figs. 5*a–b*.—JONES, KIRKBY, and BRADY, *1874*, Mon.

[37] Geis, H. L., *Jour. Paleontology*, vol. 6, no. 2, p. 179, pl. 26, figs. 2*a*, *b*, 1932.

[38] Ulrich, E. O., *Cincinnati Soc. Nat. Hist., Jour.*, vol. 13, p. 196, pl. 17, figs. 1*a–c*, 1891.

[39] Jones, T. R., and Holl, H. B., *Ann. Mag. Nat. Hist.*, vol. 3, (4), p. 213, pl. 14, figs. 7*a–c*, 1869.

Carb. Entom. Great Brit., Paleontogr. Soc., pp. 3, 7, 11, pls.—JONES, *1898*, Ann. Mag. Nat. Hist., (7), vol. 1, pp. 333–338, 341, pl. 17.

Carapace ovate, oblong oval or pyriform, produced in front into a more or less prominent beak with a subjacent hollow or notch; carapace often apiculate behind; the oval muscle spot frequently apparent on the exterior when the test is somewhat exfoliated, muscle spot located at the center of the valve or in front of the center, composed of radially arranged rays.

Genotype: *Cypridina reynaudii* Milne-Edwards. Range of *Cypridina*, Ordovician (?) to the present.

Brady[40] says that the cypridinids are "notched at the antero-inferior angle so that when the valves are closed there remains still a large aperture for the protrusion of the lower antennae." He notes that "the shape of shell, too, is usually very different in the two sexes, the male being very long and slender in comparison with the female."[41] In regard to the differences between the young and the adult molts it is said that *Cypridina brevimentum* is

deeply cut by a sinus in front, with the lower (antero-ventral) region sloping away downwards and backwards with a curved outline. The smaller (younger) and most oval specimens have the greatest loss in this region and

[40] Brady, G. S., *Lin. Soc., Trans.*, vol. 26, p. 462, 1868.

[41] Brady, G. S., *Voyage H. M. S. Challenger, pt. 3, Report on the Ostracoda*, pp. 151, 152, 1880.

EXPLANATION OF PLATE 17

All figures except 7*a*, *b* are ×30;
7*a*, *b* are ×9.09

FIGS. 1*a–c*—*Basslerella crassa* Kellett, n. sp. 1*a*, *b*, The dorsum and the right side of the holotype, anterior to the right in both figures; 1*c*, interior left valve paratype, note the calcareous inner lamella around the ends and the venter, and the faint teeth at the center of the dorsum. Elmdale formation; 1*a*, *b*, Loc. 64; 1*c*, Loc. 61. (p. 156)

2*a*, *b*—*Basslerella rothi* Kellett, n. sp. Dorsum and right side carapace holotype. Elmdale formation, Loc. 64. (p. 157)

3*a–d*—*Acratia typica*(?) Delo. Right sides carapaces with the dorsal views above. 3*a*, *b*, Elmdale formation, Loc. 60X, anterior extremity broken; 3*c*, *d*, Grenola formation, Loc. 42. (p. 140)

4*a–d*—*Haworthina bulleta* (Harris and Lalicker). Right sides carapaces with the dorsal views above each. Grenola formation, Loc. 42. (See text figs. for overlap) (p. 161)

5*a–g*—*Basslerella firma* Kellett, n. sp. Holotype 5*c*, *d*. 5*b*, *d* and *e* right sides carapaces with the dorsal view above each. 5*e*, Lateral view right valve. 5*a*, *b*, Falls City(?) limestone, Loc. 40; 5*c*, *d*, *f*, *g*, Elmdale formation, Loc. 60X; 5*e*, Wreford formation, Loc. 57. (p. 156)

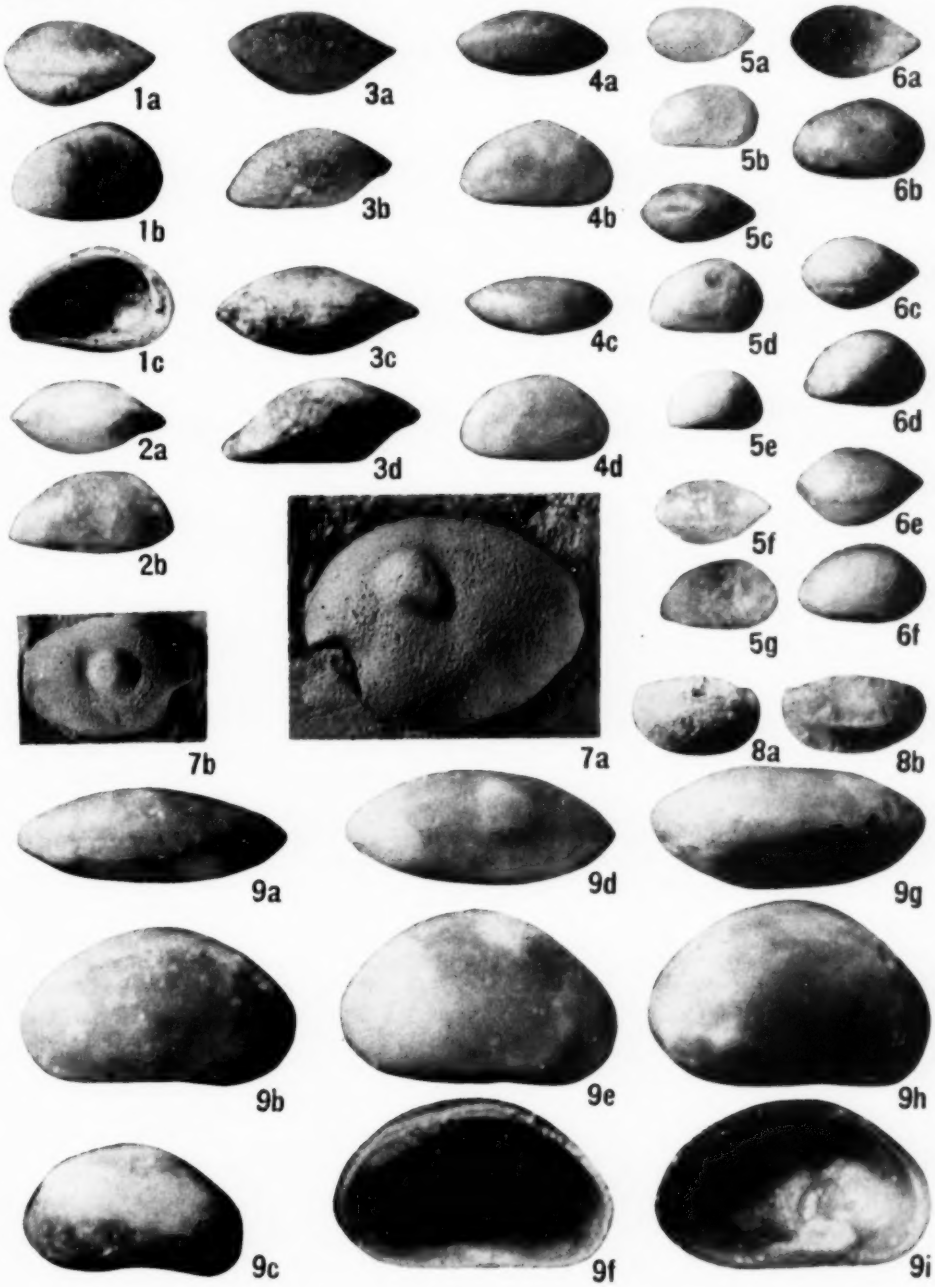
6*a–f*—*Basslerella obesa* Kellett, n. sp. Holotype 6*e*, *f*. Right sides carapaces with the dorsal views above each. Wakarusa limestone, Loc. 15. (p. 156)

7*a*—*Cypridellina newelli* Kellett, n. sp. Left valve holotype, top Wyandotte formation, collected by Dr. N. D. Newell. (Note that figures 7*a–b* are magnified only about one-third as much as the rest of the figures on this page.)(p. 153)

7*b*—*Cypridellina newelli*(?) Kellett, n. sp. Right valve imbedded in limestone. Wyandotte formation. (p. 153)

8*a*, *b*—*Kellettella navicula* Delo. 8*a*, Single valve; 8*b*, carapace tilted to show ventral gash-like depression. Middle Pennsylvanian, Loc. 24A. (p. 159)

9*a–i*—*Silenites lenticularis* (Knight). 9*b*, *e*, *h*, Right side carapaces with the corresponding dorsal view above each to show the variation in length-height ratio and thickness among specimens from the same horizon and locality. 9*c*, Right valve, note normal pores. 9*f* and 9*i*, Interior of left valve tilted at slightly different angles; 9*f* shows the marginal groove along the dorsum, and 9*i* the large circular depressed muscle spot with the pattern of two parallel vertical rows, the white object near the venter of this valve is an attached foraminifera. 9*a–h*, Americus limestone, Loc. 70; 9*c–i*, Elmdale formation, Loc. 60. (p. 151)



Kellett, Pennsylvanian and Permian Ostracodes

the relatively most projecting beak; and thus present an even more chinless outline than the larger individuals.[42]

CYPRIDINA SUBOVATA Ulrich and Bassler

Cypridina subovata ULRICH and BASSLER, *1906*, U. S. Nat. Mus., Proc., vol. 30, p. 162, pl. 11, figs. 23–26. Lawrence shale, Middle Pennsylvanian, Lawrence, Kansas. —BEEDE and ROGERS, *1908*, Kansas Univ. Geol. Survey, charts pp. 328, 372, 384. Fort Scott limestone to the Kickapoo limestone beneath the Lawrence shale.—GRABAU and SHIMER, *1910*, North American Index Fossils, text fig. 1667.

This species was not found in my collection.

Genus CYPRIDELLINA Jones, 1873

Cypridellina JONES, *1873*, Monthly Micr. Jour., vol. 10, p. 74.—JONES, KIRKBY and BRADY, *1874*, Mon. Brit. Foss. Biv. Entom. Paleontogr. Soc., p. 25.—JONES and KIRKBY, *1886*, Geol. Soc. London, Proc., vol. 9, p. 498; *1886*, Geol. Soc. London, Quart. Jour., vol. 42, p. 410.—JONES, *1898*, Ann. Mag. Nat. Hist., (7), vol. 1, pp. 333–344, pl. 17.

Jones, Kirkby and Brady (1874) give the following description:

Carapace suboviform; notched in front; produced in the antero-ventral region; the valves locally swollen into a tubercle or circular subcentral hump above the median line.

The hump or node is usually central or anterior to the center in this genus.

Genotype by subsequent designation: *Cypridellina clausa* Jones and Kirkby, Carboniferous, Ireland, first species described. Range of *Cypridellina*, Mississippian, Pennsylvanian and possibly Permian as Gemmellaro in 1890 described both *Cypridellina* and *Cypridella* from the "Permo-Carboniferous" of Italy.

Cypridellina is distinguished from *Cypridina* by the presence of a subcentral hump or node, and from *Cypridella* by the lack of the dorsal sulcus which occurs behind the node in *Cypridella*.

[42] Jones, Kirkby, and Brady, *Paleontogr. Soc., Mon.*, p. 15, 1874.

CYPRIDELLINA NEWELLI Kellett, n. sp.
Plate 17, figure 7*a*, figure 7*b*(?)

Carapace very large, broadly ovate, and each valve very convex; in lateral view the dorsum rounding evenly into the prominent anterior beak located at the mid-height of the valve, the posterior narrowly rounded, a large hemispherical node located in the antero-dorsal quarter with the valve slightly depressed along the posterior of its base. The holotype is 4 mm. long and 3 mm. high.

Specimens of this species are so large that they can be seen with the unaided eye on freshly broken surfaces of the pure, white fine-grained limestone in which they occur as partially exfoliated specimens or as molds or casts. The small specimen, fig. 7*b*, doubtfully referred to *C. newelli*, has its lower edge imbedded in limestone making it appear narrower than it really is. The node is also more centrally located than in the holotype, but this may be due to the fact that it is a smaller and therefore perhaps a younger molt.

Cypridellina newelli is the first species of this genus to be described from America. However, it may be conspecific with one of the forms found by Beede and Rogers in Kansas. In 1908 they listed[43] *Cypridella americana* Rogers, n. sp., a *nomen nudum* since it was never described or figured and no type is in existence, as being abundant in Fort Scott limestone and occurring at a number of horizons up to the Kickapoo limestone below the Lawrence shale and also another *Cypridella* sp. from the Galesburg shale to the Iola (possibly the Argentine) limestone, and a *Cypridinella* sp. from the Ft. Scott and Iola limestones.

Range: Wyandotte formation to Stanton formation, upper Missouri series, Middle Pennsylvanian. Top Argentine limestone, lower Wyandotte formation, driveway to Camp Naish, 2 miles east of Bonner Springs (see *Kansas Geol. Soc., Guidebook*, 1932), Newell's Loc. 121,

[43] Beede, J. W., and Rogers, A. F., *Kansas Univ. Geol. Survey*, vol. 9, pp. 339, 345, 372, 384 and chart facing p. 328, 1908.

4 specimens. Top Wyandotte formation, 1¼ miles north of the SE. cor. sec. 19, T. 15 S., R. 23 E., Newell's Loc. 52, 6 specimens, including the holotype and the other figured specimen. Merriam limestone, lower Plattsburg formation, center south edge sec. 8, T. 10 S., R. 23 E., 1 specimen. Spring Hill limestone, upper Plattsburg formation, big quarry on highway 2 miles north of Garnett, Newell's Loc. 42, 1 specimen. Captain Creek limestone, lower Stanton formation; NE. cor. sec. 4, T. 13 S., R. 21 E., road cut, Newell's Loc. 65, 2 specimens; NE. cor. sec. 36, T. 11 S., R. 22 E., 1 specimen; cen. E. side sec. 10, T. 22 S., R. 20 E., Newell's Loc. 75, 1 specimen; upper Captain Creek limestone, Railroad cut one-half mile east of Linwood, Leavenworth County, Kansas, Newell's Loc. 47, 1 specimen.

The holotype is in the collection at the Geological Museum of the University of Kansas.

The name is in honor of Dr. Norman D. Newell who collected these specimens while making detailed studies of the upper part of the Missouri series in Kansas and Missouri.

Family ENTOMOCONCHIDAE Ulrich,[44] 1900

Genus OFFA Jones and Kirkby, 1874

Offa JONES, *1873*, Geol. Soc. London, Quart. Jour., vol. 29, p. 409.—JONES, KIRKBY and BRADY, *1874*, Mon. Carb. Entom. Great Brit., pt. 1, p. 53.—JONES and KIRKBY, *1886*, Geol. Assoc. (London), Proc., vol. 9, p. 501.—JONES, *1898*, Ann. Mag. Nat. Hist., (7), vol. 1, p. 341.

Description by Jones and Kirkby, 1874.

Carapace equivalve(?), subglobose, nearly equilateral, truncate in front and impressed by a subcentral inturning of the anterior edge of each valve representing the cypridinal notch and equivalent to the upper gape in *Entomoconchus*.

Genus monotypical, genotype *Offa barrandiana* Jones and Kirkby, 1874, Carboniferous, Ireland.

OFFA PERMINUTA (Kellett)

Paraparchites(?) perminutus KELLETT, *1933*, Jour. Paleontology, vol. 7, p. 67, pl. 13, figs. 31, 32.

After H. L. Geis in a written communication had expressed very strong doubts

[44] Ulrich, E. O., in *Text Book of Palaeontology* by Karl A. Von Zittel, p. 647, 1900.

EXPLANATION OF PLATE 18

All figures ×30

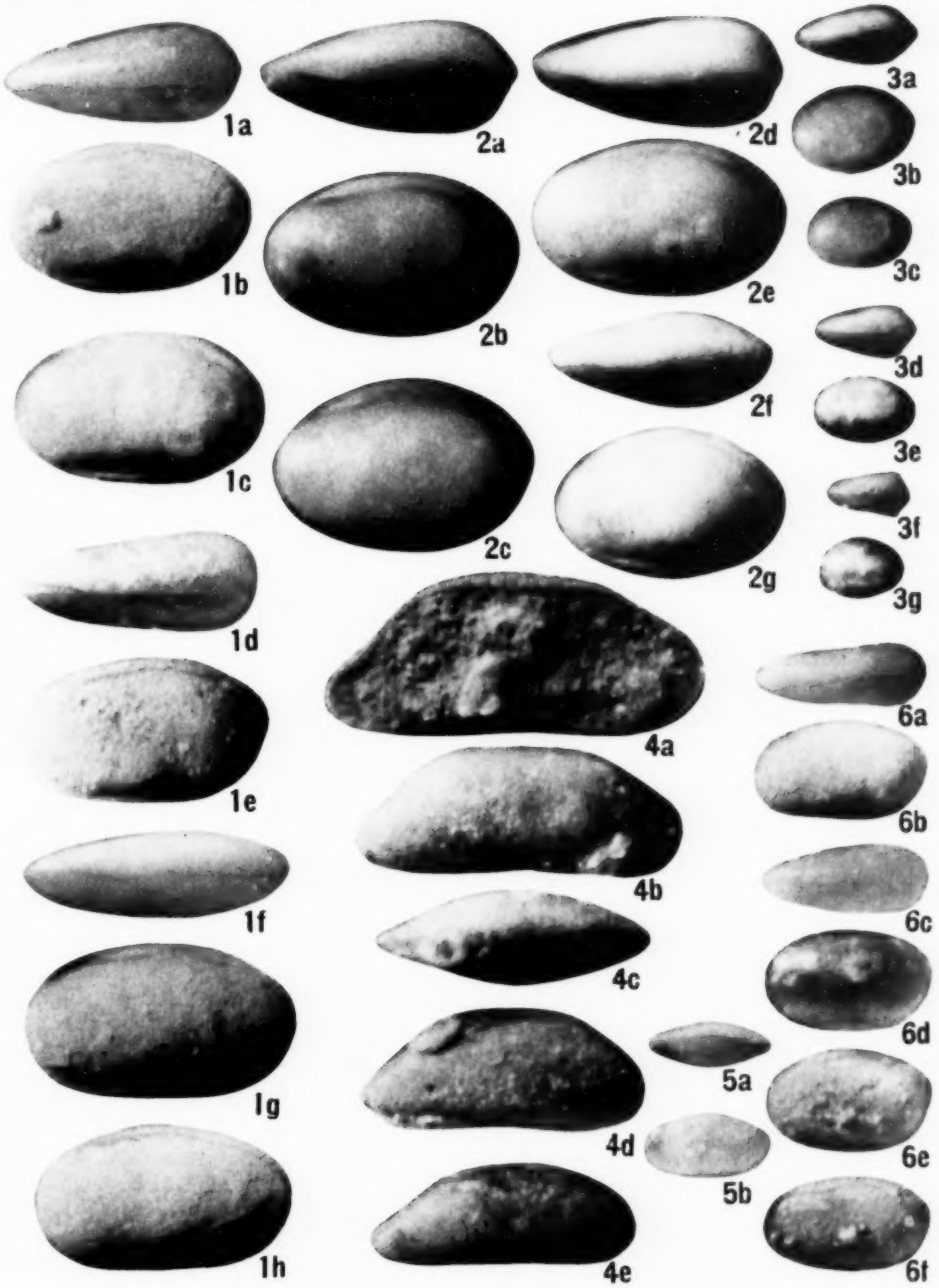
FIGS. 1*a–h*—*Cavellina nebrascensis* (Geinitz). 1*a–e*, Females; 1*f–g*, male; 1*h*, male or young female. Note that the male is relatively more elongate than the female and that the posterior end in both side and dorsal views is narrower than that of the female. 1*c*, The left side of the cyrioplesiotype, is "almost the exact image of the holotype." The posterior end of each figure is to the right, and each dorsal view has the lateral view of the same carapace just below it. 1*a–c* and 1*f–h* are from the Elmdale formation at Loc. 65; 1*d*, *e* is from the same formation at Loc. 64. (p. 146)

2*a*–3*g*—*Cavellina fittsi* Kellett, n. sp. Holotype, 2*a*, *b*. Adult females, figs. 2*a–e*. Young molts, figs. 2*f*–3*g*; note the posterior ridges on the youngest specimens. The posterior end of each figure is to the right, and each dorsal view has the lateral view of the same carapace just below it. All specimens from the Howard formation, Loc. 25. (p. 147)

4*a–e*—*Bairdia glennensis* Harlton. 4*a*, Interior left valve; 4*b*, right valve; 4*c*, *d*, dorsal and right lateral view carapace; 4*e*, right lateral view carapace. Note that the earliest molt is more elongate and tapering posteriorly than the adult molts. Elmdale formation, Loc. 64. (p. 133)

5*a–b*—*Cavellina chasensis* Kellett, n. sp. Dorsal view and left side carapace holotype. Wreford formation, Loc. 57. (p. 148)

6*a–f*—*Cavellina edmistonae* (Harris and Lalicker). 6*a–e*, Left sides carapaces with the corresponding dorsal view of each specimen above it. 6*f*, View left side carapace tilted dorsally to show the dorsal overlap. 6*a*, *b*, Grenola formation, Loc. 42; 6*c–f*, Elmdale formation, Loc. 60. (p. 147)



Kellett, Pennsylvanian and Permian Ostracodes

as to this species being a *Paraparchites*, some further study was made with the result that its correct place is now believed to have been found in the genus *Offa*. The "indentation of the hinge line" mentioned in the original description of this species is probably the "inturning of the anterior edge" of the generic description of *Offa*. Thus reoriented with the depression at the front instead of the dorsum, the specimen illustrated in fig. 32 shows the anterior at the top, the posterior at the bottom, the dorsum at the right and the venter at the left, and fig. 31 is a view of the anterior end instead of the dorsum. Fig. 32 oriented in this manner has an outline closely resembling that of the genotype, *O. barrandiana*. *O. perminuta* lacks the very faint antero-dorsal node or "low boss" and oblique anterior impression of *O. barrandiana*. *O. perminuta* is the second species referred to this genus.

O. perminuta which is common in the Lower and lower Middle Pennsylvanian has been found in rare cases in deep wells of central Kansas as high as the Howard and Emporia formations, Upper Pennsylvanian.

Family CYTHERIDAE Baird, 1850

Genus BASSLERELLA Kellett, new genus

Carapace small, subtriangular in lateral view; venter almost straight, dorsum arched or slightly angled, anterior end broadly rounded or angled and posterior end very low and narrowly rounded to rather pointed; greatest height anterior to the center; greatest thickness central or posterior to the center; venter broad and flat; in dorsal view the posterior end is broader than the anterior end which may be compressed; left valve larger than the right and overlapping it except in the post-dorsal region where the hinge line is often slightly depressed, overlap slight except along the anterior and the antero-dorsal portions; ventral overlap narrow and almost straight, slightly wider in front of the center; left valve grooved on the inner edge at and just in front of the center of the dorsum to receive the right valve, the genotype showing faint vertical striations or teeth in the central and widest part of this groove, the striations being coarsest and best defined at the anterior of the groove; calcareous inner lamella of medium and even width around the venter and the ends, only slightly developed dorsally and apparently modified by the hingement; line of concrescence paralleling and lying in close proximity to the inner margin of the calcareous inner lamella; outer surface of carapace smooth except for some fine lengthwise striations observed on two species.

Genotype: *Basslerella crassa* Kellett, n. sp., Elmdale formation, Early Permian, Kansas. Range, Pennsylvanian and Permian.

The character of the right hinge is not known because no well preserved right valves had been found. Single valves are of rare occurrence and the above description of the internal structure is based entirely on the specimen of *B. crassa* figured in Pl. 17, fig. 1*c*. The portion of the calcareous inner lamella which is between the inner margin and the line of concresence appears in the photograph of the above mentioned specimen as a narrow white line.

Basslerella is quite similar to the Cretaceous to Recent genus *Cytheridea* Bosquet, 1852; and after a study of the genoholotype of *Basslerella* both Alexander (verbal communication) and I consider that members of this genus are the direct ancestors of the *Cytheridea*. These genera are alike not only in shape and to some degree in overlap but the character of the inner lamella and the line of concrescence are apparently identical in both genera, and the faint hinge teeth seen on the left valve of *B. crassa* evidently forecast the crenulated bar commonly found on the left valve of *Cytheridea*. However the more primitive character of the hinge teeth and the lack of any overlap in post-dorsal region of *Basslerella* serve to differentiate this older genus from the *Cytheridea*.

The genus *Bairdianella* Harlton lacks the prominent anterior overlap and the flat venter characteristic of *Basslerella*. *Basslerella* has a lower and less extended anterior than the genus *Acratia* Delo and also lacks the pronounced ventral overlap of *Acratia*.

Bythocyrpris (?) *rostrata* Knight,[45] because of its flat venter and likeness to *Basslerella rothi* Kellett, n. sp., may belong to this genus and will be referred to as *Basslerella*(?) *rostrata* (Knight).

The genus *Basslerella* is characterized by the flat venter, by the partial overlap of the left valve over the right, and by the greatest thickness being at the narrowest end.

The name is in honor of Dr. R. S. Bassler, to whom, with Dr. E. O. Ulrich, we owe much of our knowledge of the Paleozoic ostracodes of America.

BASSLERELLA CRASSA Kellett, n. sp.
Plate 17, figures 1*a–c*

Carapace short and subtriangular in lateral view, anterior end broadly rounded, posterior end blunt and low, dorsum broadly angled at the point of greatest height just in front of the center, venter weakly curved upward at the posterior end; venter broad and flat so that the closed carapace rests easily upon it; in dorsal view the carapace is broadly angled at the posterior end, widest behind the center and tapering rapidly to the pointed anterior end; post-dorsal area somewhat flattened with a slightly indented hinge line; anterior and anterodorsal overlap prominent and continuous with the ventral overlap; venter shows fine lengthwise striations. Measurements of the figured specimens: length 0.67 mm., height 0.45 mm., width 0.38 mm.; length 0.70 mm., height 0.46 mm.

Lower Permian. Elmdale formation, Loc. 61, 1 specimen; Loc. 64, 9 specimens. Holotype, U.S. Nat. Mus. No. 90122, paratype No. 90123.

[45] Knight, J. B., *Jour. Paleontology*, vol. 2, p. 328, pl. 44, figs. 1*a–c*, 1928.

BASSLERELLA OBESA Kellett, n. sp.
Plate 17, figures 6*a–f*

B. obesa is only half as large as *B. crassa*, and in dorsal view it is usually more inflated, the width sometimes equalling the height. The greatest width is nearer the center than in *B. crassa*, and in lateral view the dorsum of *B. obesa* is often rounded rather than broadly angled. *B. obesa* occurs lower in the section than *B. crassa*. Measurements of the figured specimens:

Figs.	Length	Height	Width
6*a, b*	0.57 mm.	0.34 mm.	0.31 mm.
6*c, d*	0.52 mm.	0.32 mm.	0.30 mm.
6*e, f*	0.55 mm.	0.33 mm.	0.33 mm.

Upper Pennsylvanian. Wakarusa limestone, lower part of the Wabaunsee group, Loc. 15, 3 specimens. Also found in deep wells in southern Kansas at this horizon and in the Emporia limestone just above. Holotype and paratypes, U.S. Nat. Mus. No. 90124.

BASSLERELLA FIRMA Kellett, n. sp.
Plate 17, figures 5*a–g*

B. firma is quite like *B. crassa* and *B. obesa* but it is smaller than either and even in its widest form less inflated.

Measurements of figured specimens

Figs.	Length	Height	Width
5*a, b*	0.46 mm.	0.28 mm.	0.24 mm.
5*c, d*	0.50 mm.	0.31 mm.	0.25 mm.
5*e*	0.41 mm.	0.25 mm.	
5*f, g*	0.52 mm.	0.30 mm.	0.27 mm.

An undescribed species of *Basslerella* resembling *B. firma* was found in the Stanton formation, Middle Pennsylvanian at Loc. 22. This species is, however, more elongate and pointed at the ends than *B. firma* in both side and dorsal views. Only three specimens were found, none of which were well enough preserved to be used as a type.

Uppermost Pennsylvanian and Permian. Falls City(?) limestone, Loc. 40, 1 specimen. Americus limestone, Loc. 70, 3 specimens. Elmdale formation: Loc. 60, 3 specimens; Loc. 60X, 11 specimens; Loc. 61, 1 specimen; Loc. 64, 34 specimens; Loc. 65, 2 specimens. Wreford formation, Loc. 57, 1 specimen. Winfield

formation, Loc. 75, 4 specimens. Holotype, U.S. Nat. Mus. No. 90125 (Loc. 60X), paratypes No. 90126 (Loc. 40) and 90127 (Loc. 57).

BASSLERELLA ROTHI Kellett, n. sp.
Plate 17, figures 2*a–b*

Carapace small, in lateral view subtriangular; venter slightly convex, sloping upward especially in the anterior third, dorsum slightly angled about one-third the distance from the anterior, posterior rounding evenly down to the venter which it meets at a weakly acute angle making a low beak, anterior end broadly angled below the mid-height of the valve; carapace in dorsal view thick with the anterior end compressed; dorsum faintly depressed along the hinge line; apparently a slight overlap of the larger valve along the dorsal slopes but no well-preserved specimens found; fine lengthwise striations on the venter as occur on *B. crassa*. Measurements of the figured specimen: length 0.71 mm., height 0.36 mm., width 0.32 mm.

B. rothi is more elongate than *B.*(?) *rostrata*, a little less compressed anteriorly, and in lateral view the anterior beak is less pointed and lower. *B. rothi* is much larger and more elongate than *B. firma* n. sp., Pl. 17, figs. 5*a–g*, the greatest height is nearer the anterior, the ends more pointed in lateral view, and in dorsal view the anterior much more compressed.

Lower Permian, Elmdale formation, Loc. 64, 8 specimens. Holotype, U.S. Nat. Mus. No. 90128.

The name is in honor of Mr. Robert Roth of Tulsa, Oklahoma, who has described many species of ostracodes from the Mid-Continent region.

Genus MONOCERATINA Roth, 1928

Monoceratina ROTH, *1928*, Jour. Paleontology, vol. 2, p. 15, text figs. 1*a–3c*.—ALEXANDER, *1933*, Jour. Paleontology, vol. 7, pp. 202–204, pl. 27, figs. 15*a, b;* Jour. Paleontology, vol. 8, pp. 57–67, pl. 8.

Triceratina UPSON, *1933*, Neb. Geol. Survey, Bull. 8, pp. 29–30, pl. 3, figs. 1*a–c*. Holotype of the genotype examined.

Carapace in lateral view subrectangular with the ventral margin approximately paralleling the straight hinge or slightly rounded or oblique; in lateral view anterior end broadly rounded; posterior end tapering, often to a very pronounced degree; carapace usually rather thick in edge view with rapidly tapering ends; a prominent horn-like ventral protuberance located more or less posterior to the center of the carapace and projecting outward and downward or backward; often a faint vertical dorsal sulcus located centrally or slightly to the anterior; other surface ornamentation such as nodes, ridges and spines are found in the later Carboniferous and Cretaceous species; surface of the Carboniferous species finely pitted, and of the Cretaceous species sometimes reticulated; right hinge grooved to receive the left; although essentially equivalved Roth notes a tendency for some right valves to be slightly grooved ventrally to receive the left; Alexander states that "the line of concrescence and inner margin coincide throughout, and their course is near and parallel to the outer margin of the shell."

Genotype by original designation: *Monoceratina ventrale* Roth. Wapanucka limestone, Lower Pennsylvanian, Pontotoc County, Oklahoma.

Middle Devonian[46] to Oligocene.

In the above discussion the orientation used by Alexander, which is the reverse of that of earlier authors, is followed.

The inconspicuous nodes of *Triceratina* Upson are here, as in the work of Alexander and of Harris and Lalicker, evaluated as merely specific rather than generic characters; and therefore *Triceratina* is given as a synonym of *Monoceratina*.

M. ventrale Roth is probably a synonym of *M. ardmorensis* (Harlton).[47] They

[46] Warthin, Aldred S., *Univ. Michigan, Mus. Pal., Contr.*, vol. 4, no. 12, p. 207, pl. 1, fig. 1, 1934.

[47] Harlton, B. H., *Jour. Paleontology*, vol. 1, p. 211, pl. 33, figs. 14*a–c*, 1927. *Am. Jour.*

occur at the same horizons, and differ only in the presence of a faint sulcus on *M. ventrale;* the lack of this sulcus on *M. ardmorensis* may be due to a difference in preservation or degree of development.

Monoceratina tennesseensis (Ulrich and Bassler) (new combination for *Bursulella*(?) *tennesseensis* U. and B.),[48] from the Lower Mississippian Ridgetop shale, is about one-third longer than the Permian *M. lewisi* Harris and Lalicker. The specimens of *Monoceratina* in the Pennsylvanian are also smaller than those of the Early Mississippian, and they continue to diminish in size through the Late Pennsylvanian and the Permian. This decrease in size throughout the Carboniferous is a characteristic which is noted in this paper in many other ostracode genera. *Bythocythere youngiana* Jones and Kirkby[49] and possibly *B. antiqua* J. and K.[50] should in all probability be referred to the genus *Monoceratina.*

A relationship between *Monoceratina* and the Mississippian genus *Janischewskya* Batalina[51] from Russia and Scotland is indicated by their similar lateral outline, slight dorsal sulci, and funnel-shaped ventral protuberances which point donward and backward. The ventral protuberances of *Janischewskya* are, however, located nearer the anterior than in *Monoceratina,* and this genus is further differentiated by the row of spines bordering the free edges, which spines are sometimes long and club-shaped.

Sci., vol. 18, p. 270, pl. 2, figs. 18*a*, *b*, Sept. 1929. *Jour. Paleontology*, vol. 7, pp. 21–22, pl. 7, figs. 14*a*, *b*, 1933.

[48] Bassler, R. S., *Tenn. Div. of Geol., Bull.* 38, pl. 27 (no description), 1932.

[49] Jones, T. R., and Kirkby, J. W., *Ann. Mag. Nat. Hist.*, (5), vol. 18, pp. 249–269, pl. 9, figs. 4*a–b*, 1886.

[50] *Idem*, figs. 5*a–b*.

[51] Batalina, M., *Bulletins du Comité Géologique* (Leningrad), vol. 43, no. 10, part 47, pp. 1332, 1336, pl. 22, fig. 20 (mislabeled 23) and fig. 24; pl. 23, figs. 10, 11, 1924 (1926). Latham, Mary A., *Royal Soc. Edinburgh, Trans.*, vol. 57, pl. 2 (no. 12), p. 365, text fig. 11, 1932–33 (1932).

MONOCERATINA LEWISI Harris and Lalicker
Plate 16, figures 4*a–b*

Monoceratina lewisi HARRIS and LALICKER, *1932*, Am. Midland Nat., vol. 13, p. 398, pl. 36, figs. 6*a*, *b*. Fort Riley limestone, Permian, Butler County, Kansas.

Triceratina wrefordensis UPSON, *1933*, Neb. Geol. Survey, Bull. 8, (2), pp. 29–30, pl. 3, figs. 1*a–c*. Wabaunsee group, Upper Pennsylvanian to the Wreford formation, Permian, Kansas.

Carapace very small; elongate for the genus; the posterior end very compressed and tapering and usually more or less broken as that part of the shell is thin and delicate; ventral protuberance long and at the end pointed; a slight dorsal sulcus just in front of the center, with an inconspicuous node just behind it near the hinge line; another larger and slightly more conspicuous node in the antero-dorsal region; a fourth faint node is sometimes found at the antero-cardinal angle; anterior margin bordered by a narrow almost flat area; surface finely reticulated; valves so small and thin that no hinge structure can be seen. Measurements of the figured specimens: fig. 4*b*, length reconstructed, 0.85 mm.; height 0.36 mm.; thickness of the specimen, fig. 4*a*, measured through the spine 0.36 mm.

The small early molts do not show the dorsal nodes, only the two ventral nodes, which seemingly indicates their descent from some simple form such as *M. ardmorensis* (Harlton) of the Lower Pennsylvanian. The only difference between the forms described as *M. lewisi* and *Triceratina wrefordensis* is the presence of an additional small faint node at the antero-cardinal angle of *M. lewisi* which is much less prominent than in the figure. Because these two forms are identical in all other respects and are found occurring together at many horizons, I believe that these forms are conspecific, the presence or absence of the faint node being an inconsequential variation due perhaps to age.

Range, at least as low as the Howard limestone, lower Wabaunsee group, Upper Pennsylvanian; to the Winfield

formation, Permian. Most common in the Permian. The nodes are as prominent and well developed on the Howard specimens as those on the Permian specimens. Kanwaka shale, lower Shawnee group, Loc. 78, 3 small and doubtful specimens. Deer Creek formation, Loc. 18, 1 small and doubtful specimen. Howard formation, Loc. 25, 11 specimens. Wakarusa(?) limestone, Loc. 15, 1 small specimen. Falls City(?) limestone, Loc. 40, 8 specimens. Americus limestone, Loc. 70, 4 specimens. Elmdale formation: Loc. 60X, 3 specimens; Loc. 61, 2 specimens; Loc. 64, 7 specimens; Loc. 65, 1 specimen. Neva formation: Loc. 66, 1 specimen; Loc. 67, 7 specimens. Cottonwood limestone: Loc. 44, 11 specimens; Loc. 76, 6 specimens. Wreford formation: Loc. 43, 12 specimens, Loc. 46, 5 specimens; Loc. 47, 2 specimens; Loc. 57, 3 specimens. Fort Riley limestone, Loc. 45, 28 specimens. Winfield formation Loc. 56, 1 specimen. Plesiotypes, U.S. Nat. Mus. Nos. 90129 (Loc. 46) and 90130 (Loc. 67).

Genus KELLETTELLA Delo, 1930

Kellettella DELO, *1930*, Jour. Paleontology, vol. 4, no. 2, p. 176, pl. 13, figs. 14*a–c*.—GEIS, *1932*, Jour. Paleontology, vol. 6, no. 2, p. 187, pl. 26, figs. 10*a*, *b*.

Carapace in lateral view subovate and rather elongate, dorsal margin straight or slightly convex, ends rather evenly and broadly rounded, ventral margin straight or slightly curved, greatest height posterior to the center; greatest thickness central; dorsal view lanceolate; right valve larger than the left and moderately overlapping it around the free margins; hinge line long, straight and impressed within a very deep furrow; free margins sometimes bordered by a slight ridge or a thick flange; surface smooth.

Genotype by original designation, *Kellettella navicula* Delo, early Middle Pennsylvanian, Texas. Range: Salem limestone of Upper Mississippian age to Middle Pennsylvanian. Pennsylvanian representatives of this genus are much smaller than the Mississippian species, a tendency noted also in most of the other Carboniferous genera.

Kellettella is characterized by the deep dorsal furrow.

KELLETTELLA NAVICULA Delo

Plate 17, figures 8*a*, *b*

Kellettella navicula DELO, *1930*, Jour. Paleontology, vol. 4, no. 2, p. 176, pl. 13, figs. 14*a–c*. Early Middle Pennsylvanian in a deep well in Menard County, Texas.

Carapace small; in lateral view dorsum and venter slightly convex and the posterior end only very slightly the higher; cardinal angles distinct; in dorsal view carapace elongate with almost equal ends; the hinge line deeply impressed in a furrow as is characteristic of this genus; species characterized by a thick ventral flange extending about to the mid-height at each end, flange confluent with the surface of the valve or only faintly flattened, edges of the flanges thin, flanges "broader and more widely separated in the post-ventral portion"; overlap of right valve slight, most apparent at the cardinal angles in dorsal view. Measurements of the figured specimens: Pl. 17, fig. 8*a*, length 0.56 mm., height 0.34 mm.; fig. 8*b*, length 0.62 mm.

Common in the Missouri series, early Middle Pennsylvanian, and extending up into the Shawnee group, also of Middle Pennsylvanian age. Stanton formation, Loc. 22, 1 specimen; Iatan limestone, Loc. 24, 2 specimens. Plesiotypes, U.S. Nat. Mus. No. 90131.

Family CYPRIDAE Baird, 1846

Genus CARBONITA(?) Strand, 1928

Carbonia JONES, *1870*, Geol. Mag., vol. 7, p. 218.—JONES and KIRKBY, *1879*, Ann. Mag. Nat. Hist., vol. 4, (5), p. 30; *1892*, Manchester Geol. Soc., Trans., vol. 21, pt. 3, pp. 137–142, 1 pl.—LATHAM, *1933*, Roy. Soc. Edinburgh, Trans., vol. 57, pt. 2, no. 12, pp. 284–286.

Carbonita STRAND, *1928*, Archiv. fur Naturgeschichte, vol. 92, pt. A, no. 8, 1926 (1928), pp. 40, 41. A new name for *Carbonia* Jones, preoccupied Robineau-Desvoidy, 1863.

Carapace small, subreniform; dorsum arched; venter slightly concave; ends

rounded in lateral view, the anterior end lower and more narrowly rounded than the posterior; greatest height at or behind the center; posterior half thicker than the anterior; right valve larger than the left and overlapping it except along the central third of the dorsum where the hinge line is depressed (see Pl. 16, figs. 9*c* and 11*c*); the left valve sometimes seems to extend a little above the right along this depressed part of the hinge line; overlap of right valve greatest ventrally in front of the center (see Pl. 16, fig. 11*e*), and on the antero-dorsal slope just above the anterior end; shell rather thin and covered with fine pits which are sometimes obscure, pits arranged in more or less discernible horizontal rows; a circular medium sized muscle spot located in front of the center (it can be seen through the transparent valve in Pl. 16, fig. 11*f*). Single valves are of rare occurrence and any hinge and marginal structure present is still unknown.

The above is a description of the Kansas forms referred to this genus. The description of the genus *Carbonia* given by Jones and Kirkby in 1879 is as follows:

> Valves subovate, ovate-oblong, or elongate; anterior third usually smaller than the posterior; the right valve slightly larger than the left, overlapping it sometimes along the middle portion of the ventral edge. Hinge-line in the middle third of the dorsal margin, more or less defined between the anterior and posterior curved slopes of the dorsal margin. Hinge simple. Muscle-spot circular, enclosing three or four translucent spots or a lobed pattern; level or slightly depressed on the outside, somewhat hollow within. The valves are bent inwards, in some cases, near the muscle-spots, and leave slight, subcentral transverse furrows on the cast. The round and spotted muscle spot, hollow within, is a characteristic of the genus.

In several species this muscle spot is described as being anterior to the center of the valves. The surface may be smooth, pitted or finely reticulate.

Genotype by subsequent designation: *Carbonia agnes* Jones, 1870, Pennsylvanian, Wales.*

The species under consideration lack the overlap along the entire dorsal margin characteristic of *Bythocypris*. Both the Kansas and the British species are characteristically found in dark bituminous shales, although they sometimes occur in limestones.

The specimens figured in this paper resemble *Cytherellina silique* (Jones)[52] but they lack the internal ridges and the overlap is reversed. The overlap is also the reverse of that of the genus *Silenites* Coryell and Booth. They are probably congeneric and possibly conspecific with the species from the Permian called *Cythere* (?) *tyronica* Jones[53] and *C.* (?) *richteriana* Jones[53] which are not true *Cythere*. Other Carboniferous species which may be related are *Darwinula* (?) *berniciana* (Jones)[54] from the Mississippian, *Candona* (?) *kotahensis* Jones,[55] Permian or Mesozoic, and *C.* (?) *globosa* Jones.[55] These species apparently do not belong to the post-Tertiary genera to which they were referred.

CARBONITA(?) TUMIDA (Upson)
Plate 16, figures 9*a–d*

Bythocypris tumidus UPSON, *1933*, Neb. Geol. Survey, Bull. 8, (2), p. 24, pl. 2, figs. 11*a–c*. Stearns shale, Lower Permian, Kansas. Type examined.

Carapace very tumid posteriorly in dorsal view, the posterior end rounded and the anterior end pointed and sometimes slightly compressed; a short marginal ridge at the antero-ventral corner, see Pl. 16, fig. 9*d*; anterior extremity of the venter somewhat compressed and ridge-

* Bassler, R. S., and Kellett, B., *Bibliographic Index of Paleozoic Ostracoda*, p. 237, 1934.

[52] Jones, T. R., and Holl, H. B., *Ann. Mag. Nat. Hist.*, vol. 3, (4), pp. 215–217, pl. 14, fig. 2, 1869.

[53] Kirkby, J. W., *Tyns. Nat. Field Club, Trans.*, vol. 4, pp. 122–169, pl. 11, figs. 20*a–21c*, 1859. Richter, *Deutsche geol. Gesell., Zeitschr.*, pp. 216–236, pl. 5, figs. 9–10, 1867.

[54] Jones, T. R., *Hist. Berwickshire Nat. Club, Proc.*, pp. 313–326, pl. 2, figs. 4*a–b*, 1883.

[55] Jones, *Paleontogr. Soc., Mon.*, p. 127, pl. 5, figs. 23–25, 1862.

like but venter flattened at the center and just in front of the center. Measurements of the figured specimens: figs. 9*a*, *b*, length 0.78 mm., height 0.46.; figs. 9*c*, *d*, length 0.67 mm., height 0.39 mm., width 0.38 mm.

Upper Pennsylvanian and Permian. Elmdale formation, Loc. 41, 1 specimen and several doubtful mashed ones. Neva formation (or Grenola as it has lately been named) Loc. 42, 9 specimens. Wreford formation, Loc. 43, 10 specimens. One specimen was found as low as the Emporia formation in a deep well, however it was not so tumid as the holotype. Plesiotypes, U. S. Nat. Mus. No. 90132.

CARBONITA(?) TUMIDA var. MAGNA (Upson)

Plate 16, figures 11*a–f*

Bythocypris tumidus var. *magnus* UPSON, *1933*, Neb. Geol. Survey, Bull. 8, (2), pp. 24–25, pl. 2, figs. 13*a–b*. Stearns shale, Lower Permian, Kansas. Type examined.

This variety is less tumid and on the average smaller than *C. tumida*.

Measurements of figured specimens

Figs.	Length	Height	Width
11*a*, *b*	0.68 mm.	0.39 mm.	
11c–*e*	0.63 mm.	0.33 mm.	0.33 mm.
11*f*	0.64 mm.	0.34 mm.	

Middle Pennsylvanian to Lower Permian. Stanton formation, Loc. 22, 8 specimens. Iatan formation, Loc. 24, 1 specimen. Howard formation, Loc. 25, 9 specimens. Falls City (?) limestone, Loc. 40, 3 specimens. Elmdale formation, Loc. 62,1 specimen. Neva limestone, Loc. 42, 1 specimen. Plesiotypes, U. S. Nat. Mus. No. 90133 (Loc. 22) and 90134 (Loc. 25).

Genus HAWORTHINA Kellett, new genus

Carapace small, subtriangular in lateral view, greatest height anterior to the center, left valve overlaps right except in the post-dorsal region where the right valve overlaps the left.

Genotype: *Bairdia bulleta* Harris and Lalicker; Permian, Texas. Range, Permian.

This genus is very doubtfully placed in the family Cypridae.

The name is in honor of the late Dr. Erasmus Haworth, for many years the State Geologist of Kansas.

HAWORTHINA BULLETA (Harris and Lalicker)

Plate 17, figures 4*a–d*, text figures 2*a–c*.

Bairdia bulleta HARRIS and LALICKER, *1932*, Am. Midland Nat., vol. 13, p. 404, pl. 37, fig. 7. Leuder limestone, Upper Permian; Baylor County, Texas. Holotype examined.

Carapace small, subtriangular, venter straight, dorsum arched and slightly angled in front of the center, ends rounded in lateral view, posterior end slightly higher and more narrowly rounded than the anterior, carapace rather thin in dorsal view, surface smooth, left valve larger than the right and overlapping it slightly along the venter, the anterior and the antero-dorsal area, right valve overlaps the left in the center of the post-dorsal area. Measurements of the figured specimens: length 0.66 mm., height 0.37 mm., width 0.28 mm.; length 0.64 mm., height 0.37, width 0.25.

The type has the greatest height a little farther from the center than the specimens figured here, but other specimens found in the Kansas collection resemble the type closely in this respect. The overlap of the Texas specimen is incorrectly figured, the carapace should be reversed to show the maximum overlap.

Permian. Elmdale formation, Loc. 64, 11 specimens; Loc. 41 (Elmdale?) several doubtful mashed specimens. Neva limestone, Loc. 42, 50 specimens. Cottonwood limestone, Loc. 44, 1 specimen. Wreford formation, Loc. 47, 2 specimens. Plesiotypes, U. S. Nat. Mus. No. 90135.

APPENDIX

Corrections and additions to previous papers dealing with Kansas ostracodes.

JONESINA UPSONI Kellett, n. sp.

Jonesina howardensis UPSON (not KELLETT), *1933*, Neb. Geol. Survey, Bull. 8, (2), p. 48, pl. 3, figs. 9*a–d*. Stearns shale, Garrison formation, Permian; near Manhattan, Kansas.

The types of this species were examined. They are more elongate than *J.*

howardensis and lack the "antero-ventral" (post-ventral) thick overhanging flange of the "left" valve and the thickened dorsal portion of the "anterior" (posterior) node. The hinge of *J. upsoni* is also much less depressed "anteriorly" (posteriorly) than that of *J. howardensis*. The name is in honor of Mr. M. E. Upson of the Humble Oil Company, McCamay, Texas, who described the Permian ostracodes of Nebraska.

OTHER SPECIES

Jonesina subquadrata Upson (not Delo), *J. garrisonensis* Upson, *Coryella stovalli* Harris and Lalicker, and *Knoxina nebrascensis* Upson, all from the Permian of Kansas and Nebraska[56] appear after an examination of the types very evidently to belong in the synonomy of *J. bolliaformis* Ulrich and Bassler (see Part 1 of this paper, p. 80).

Jonesina bolliaformis has been found in rare instances as low as the Wakarusa limestone or the Burlingame formation in deep wells in central Kansas.

Jonesina alta Harris and Lalicker[57] from the Cottonwood limestone of Kansas is founded upon a single left valve of a narrow frilled specimen of *Hollinella nevensis* Kellett.[58] The deep sulcus which extends below the center of the valve has been filled with calcite, and the valve has been somewhat shortened by compression from the ends and bent in the post-ventral portion so that the juncture of the valves is no longer in a plane. The frill and the very large anterior node extending down to the center of the valve are typical of *H. nevensis*.

Jonesina papillosa and var. *inflata* Harris and Lalicker[59] from the Foraker of Kansas have for holotypes rather weathered single valves, so that it is almost impossible to tell whether the granules are inherent to the fossils or are calcite granules resulting from weathering. Both specimens appear a little longer than figured.

Jonesina uncialis Harris and Lalicker,[60] from the Garrison formation, Kansas. I am not at all convinced that this is not a young, frilless *Hollinella* which has been compressed from each end in the dorsal half to shorten it. The holotype, a single valve, has been contorted to at least a small degree and ventrally has a vertical open crack.

"*Jonesina distenta* Kellett," Part 1, this paper, p. 82,[61] should have read "*Ellipsella distenta* Kellett."

J. howardensis has been found in the Emporia limestone in deep wells in central Kansas.

Kirkbyina inflata Harlton[62] has been found in deep wells in central Kansas from the lower part of the Missouri series to the Lower Permian Elmdale formation. It is most common in the Missouri series.

Paraparchites oviformis Upson[63] (not Coryell and Rogatz), from the Permian of Nebraska is conspecific with *P. humerosus* Ulrich and Bassler (see Part 1, pp. 64, 65, pl. 13, figs. 1–12).

P. humerosus var. *spinosus* Upson.[64] In my opinion this variety is invalid. The posterior end of the type specimen is roughened and weathered and the "beads" are only calcite granules resulting from this weathering. They occur on the sides as well as on the margin.

Paraparchites humerosus Ulrich and Bassler, var. *kansasensis* Harris and Lalicker.[65] After examining the holotype I would not differentiate this from *P. humerosus*.

[56] Upson, M. E., *Neb. Geol. Survey, Bull.* 8, (2), pp. 47–51, pl. 3, figs. 5*a*, 9*a*, *b*, 2*a–c*, 10*a*, *b*, June, 1933.

[57] Harris, R. W., and Lalicker, C. G., *Am. Midland Nat.*, vol. 13, p. 399, pl. 36, fig. 4, 1932.

[58] Kellett, B., *Jour. Paleontology*, vol. 2, p. 201, pl. 25, figs. 2*a–c*, 1929.

[59] Harris, R. W., and Lalicker, C. G., *idem*, pp. 400, 401, pl. 37, figs. 1, 3.

[60] *Idem*, p. 399, pl. 36, fig. 5.

[61] Kellett, B., *Jour. Paleontology*, vol. 8, p. 82, 1934.

[62] Harlton, B. H., *Texas Univ., Bull.* 2901, p. 147, pl. 1, figs. 15*a–e*, 1929.

[63] Upson, M. E., *idem*, p. 13, pl. 1, figs. 3*a–b*.

[64] *Idem*, p. 12, pl. 1, figs. 2*a–b*.

[65] Harris R. W., and Lalicker, C. G., *idem*, p. 396, pl. 36, figs. 1*a*, *b*.

Pseudoparaparchites kansensis.[66] Four specimens found in the Kanwaka shale, Middle Pennsylvanian, at Loc. 78.

Hollinella nevensis Kellett[67] has been found by Upson[68] in the Wreford formation, Marshall County, Kansas. Type examined.

Hollinella, sp. A. Two specimens of this possibly new species were found in the Kanwaka shale, Loc. 78, too late to be photographed. These specimens resemble *H. gibbosa*[69] Kellett very closely but both have flat frills which are much wider than the flat frills of *H. gibbosa*.

Hollinella, sp. B. Four specimens of this possibly new species were found in the Kanwaka shale at Loc. 78. This species resembles most *H. crassamarginata* Kellett,[70] but the frill is much wider and more convex in the post-ventral region, the sulcus is deeper and at the base broader, and the surface below the sulcus is not gently convex as in *H. crassamarginata* but slopes abruptly toward the venter. The frill of *Hollinella* sp. B. is much flatter than that of either *H. shawnensis*[71] Kellett, or *H. cushmani* Kellett,[72] and, furthermore, the lower edge of the frill is grooved.

Beyrichiana Kellett, see Part 1 of this paper, p. 74, pl. 13, figs. 21, 22. This genus, established for the reception of the one species *B. permiana* Kellett, may be a synonym of *Tribolbina* Latham.[73] However, the members of *Tribolbina* occur much lower in the section in the Mississippian, and they are much larger, ranging in size from 4.5 to 9 mm. in length.

Moorites (?)[74] *minutus* (Warthin), see Part 1, pp. 104, 105. Thirteen specimens of intergrading sizes were found in the Kanwaka shale, Loc. 78. These showed that the immature molts are much thicker than the mature molts, especially at the anterior, and that the very earliest molts are almost as thick as they are high. *M. minutus* has been found in the deep wells in central Kansas no higher than the Happy Hollow limestone or the Howard formation.

Cyathus ulrichi Roth, Part 1, p. 69, correct "2 specimens" to "20 specimens." One specimen of *C. ulrici* was also found in the Elmdale formation, Lower Permian, at Loc. 64. It has been found rarely occurring as high as the Neva formation in deep wells.

Albanella gouldi Harris and Lalicker,[75] from the Wreford formation, Kansas. There is no doubt in my mind after seeing the holotype that this genus and species is founded upon an exfoliated specimen of *Amphissites centronotus* (Ulrich and Bassler), a common species at this horizon.

Amphissites dattonensis Harlton, see Part 1, pp. 93, 94; 11 specimens found in the Kanwaka shale, Middle Pennsylvanian at Loc. 78.

Amphissites minutus Upson[76] (not Roth). Type examined. This belongs to the species *A. pinguis* (Ulrich and Bassler), see Part 1 of this paper, p. 94, pl. 15, figs. 12–22, 41.

Knightina perplexa Upson[77] (not Roth) from the Gage shale below the Winfield formation, Permian, Gage County, Nebraska. An examination of the Nebraska specimen shows that it belongs to the species *K. incurva* Kellett[78] from the Permian rather than to the Middle Pennsylvanian species. It does not appear to have two rows of reticulations between the keels and the pit is obscure.

[66] Kellett, B., *idem*, p. 68.

[67] Kellett, B., *Jour. Paleontology*, vol. 3, p. 201, pl. 25, figs. 2*a–c*, pl. 26, fig. 4, 1929.

[68] Upson, M. E., *idem*, p. 35, pl. 4, fig. 6*a*.

[69] Kellett, B., *idem*, p. 207, pl. 25, figs. 3*b–c*, pl. 26, fig. 5.

[70] *Idem*, p. 206, pl. 26, figs. 3*a*, *b*.

[71] *Idem*, p. 209, pl. 25, figs. 4*a–c*, pl. 26, fig. 8.

[72] Kellett, B., *Jour. Paleontology*, vol. 7, p. 71, pl. 13, figs. 35–37, 1933.

[73] Latham, Mary H., *Royal Soc. Edinburgh, Trans.*, vol. 57, pt. 2, no. 12, p. 358, text fig. 8, 1932–33 (1932).

[74] Wilson, Charles W., *Jour. Paleontology*, vol. 7, pp. 414–416, text fig. 1, pl. 50, figs. 2*a–c*, 4*a–d*, 7–8*b*, 1933.

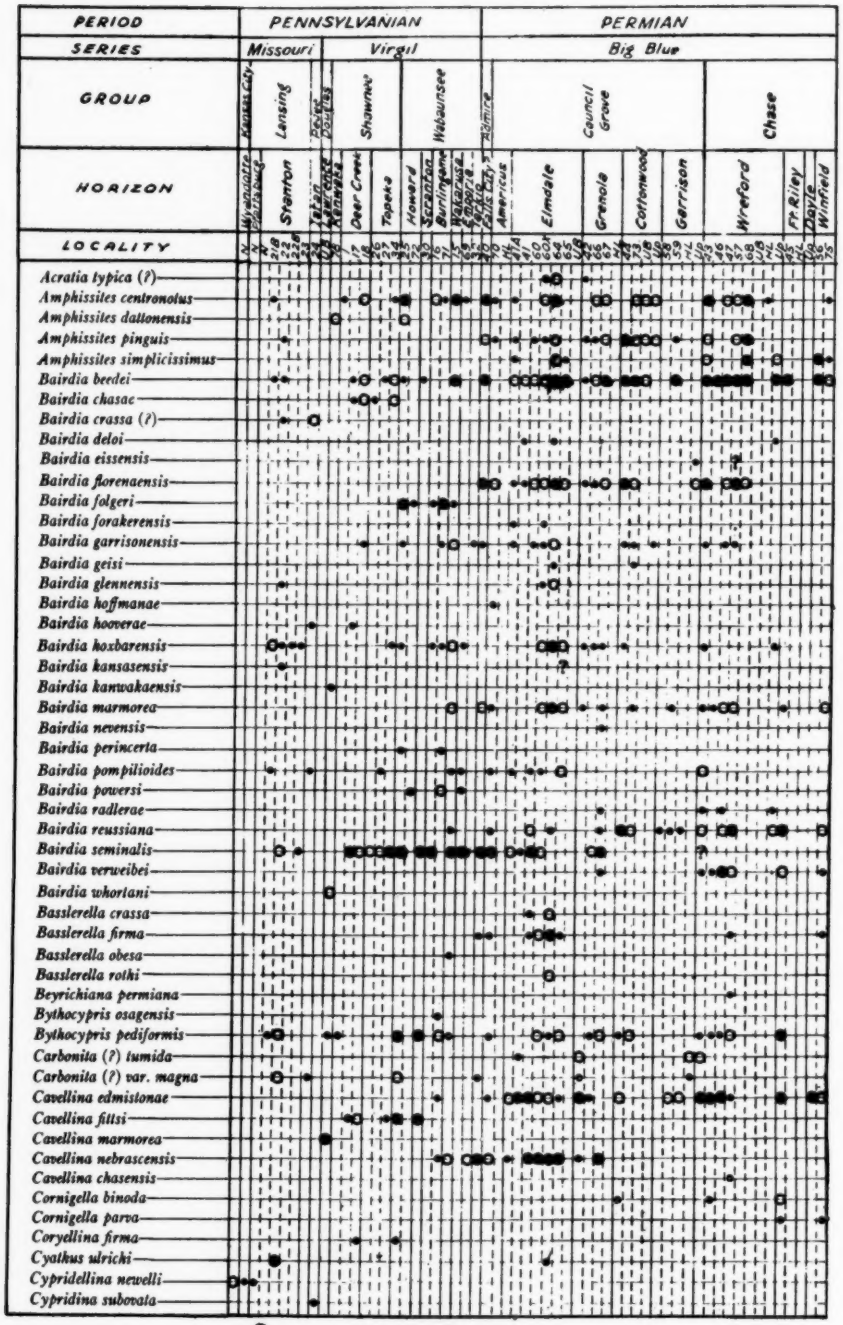
[75] Harris, R. W., and Lalicker, C. G., *idem*, vol. 13, p. 397, pl. 36, figs. 2*a*, *b*, 1932.

[76] Upson, M. E., *idem*, p. 43, pl. 3, figs. 12 *a–c*.

[77] *Idem*, p. 38, pl. 3, figs. 13*a–c*.

[78] Kellett, B., *idem*, p. 102, pl. 16, figs. 29–32.

Table Showing Range of Ostracode Species

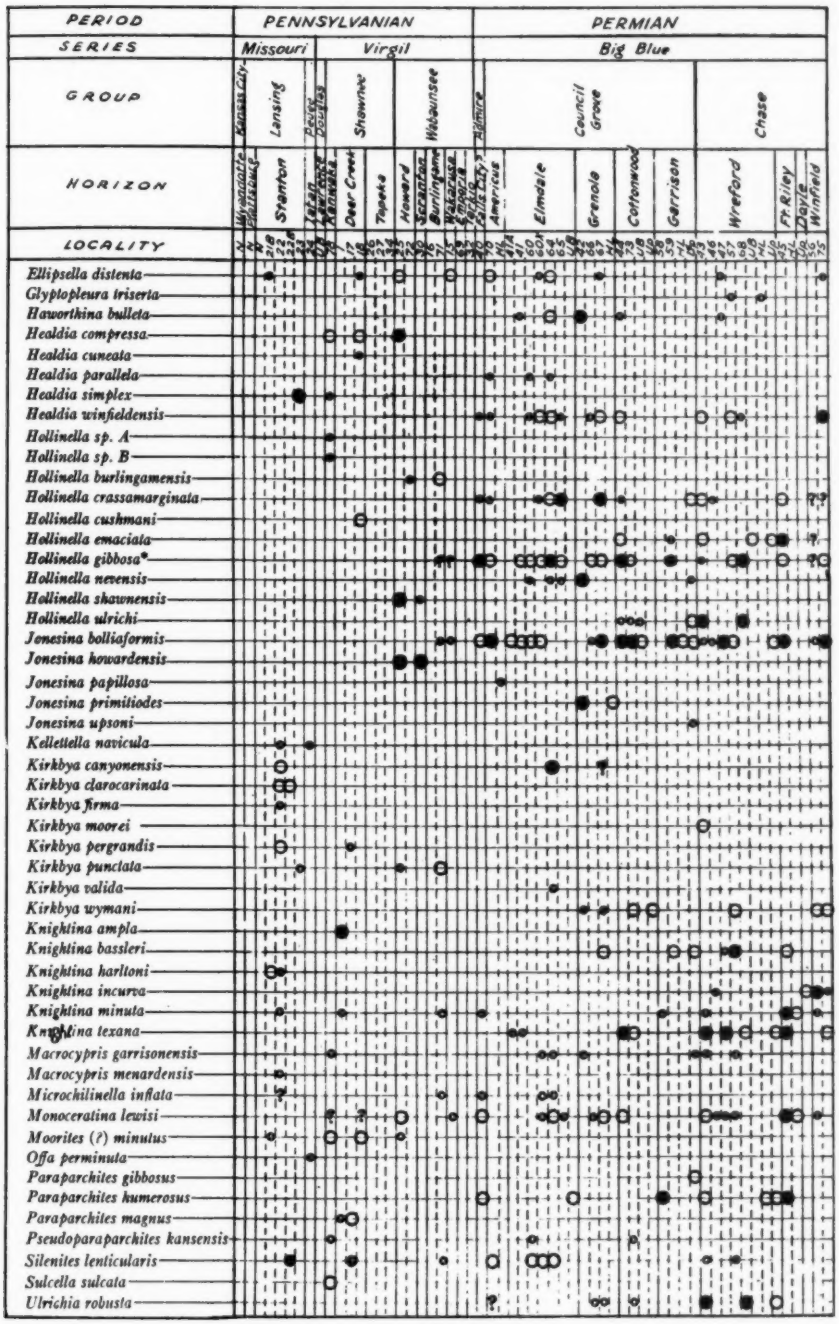


● Occurrence Abundant. ○ Occurrence Common. • Occurrence Rare.

N Described by Newell. UB Described by Ulrich and Bassler. HL Described by Harris and Lalicker.

Up Described by Upson. * All the specimens from localities 71 and 15 are small.

Table Showing Range of Ostracode Species



● Occurrence Abundant. ○ Occurrence Common. • Occurrence Rare.

N Described by Newell. UB Described by Ulrich and Bassler. HL Described by Harris and Lalicker.
Up Described by Upson. * All the specimens from localities 71 and 15 are small.

Ulrichia robusta Kellett (see Part 1, pp. 92, 93) is found lower in the section than was noted. It occurs as low as the Neva limestone and perhaps as low as the Americus limestone, basal Permian. The following localities were inadvertently omitted: Americus limestone, Loc. 70, 6 weathered and doubtful specimens. Elmdale formation, Loc. 63, 2 doubtful specimens. Neva limestone, Loc. 66, 1 specimen; Loc. 67, 4 specimens. Cottonwood limestone, Loc. 73, 3 specimens. *U. robusta* was also found by Upson[79] in the Wreford formation near Manhattan, Kansas.

[79] Upson, M. E., *idem*, pp. 45, 46, pl. 4, fig. 1*a*.

Argilloecia (?) *regularis* Delo (?), found by Upson[80] in the Hughes Creek shale of uppermost Pennsylvanian age, and the Lower Permian Garrison formation. The type which was examined is more or less weathered dorsally and the dorsal hinge line is weathered away.

NOTE.—The genus *Silenites* has a circular muscle scar and therefore probably belongs to the family Bairdiidae. The genera of the family Cytherellidae are characterized by oval muscle scars.

[80] *Idem*, p. 27, pl. 3, figs. 4*a–b*.

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THE "PALEOCENE" NAUTILOID CEPHALOPODS OF LANDANA, PORTUGUESE WEST AFRICA

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ABSTRACT

Two new species of nautiloid cephalopods from the basal Eocene of Landana on the western coast of Africa are described and illustrated and two previously described species are discussed at some length. One of the old and one of the new species represent the genus *Cimomia* whereas the other two are referable to *Hercoglossa*. Close counterparts of all four are known from the Midway group of the Gulf Coastal Plain of North America, and the correlation of the Midway with the Landana beds is sustained.

Recently Prof. T. H. Clark of McGill University, Montreal, sent me two nautiloids from the so-called "Paleocene" of Landana, which is located on the western coast of Africa in Kabinda, a northern enclave of Angola or Portuguese West Africa. These two specimens, though not complete, are remarkably well preserved and since both of them represent unnamed species they merit detailed description. Furthermore, they are so strikingly similar to forms that occur in the Midway group[1] of the American Gulf Coastal Plain that a discussion of them will be more than ordinarily interesting to American paleontologists and, at the same time, will serve to emphasize the value of nautiloid cephalopods for intercontinental correlation of Tertiary strata.

In 1913 Vincent[2] described a fairly large collection of "Paleocene" mollusks from the cliffs of Landana and gave a generalized section of the strata that outcrop there. He described a few nautiloids and I am including a discussion of them. Vincent recognized the similarity of the fossils he studied with those of the Midway and related strata, and recently Gardner[3] has correlated in a general way the Landana beds with the Midway. My study of the cephalopods confirms this correlation for close counterparts of all of the nautiloids known from Landana are to be found in the Midway; *Hercoglossa clarki* is very similar and, therefore,

[1] The nautiloid cephalopods of the Midway group have recently been monographed by Miller and Thompson (*Jour. Paleontology*, vol. 7, pp. 288–324, pls. 34–38, 1933).

[2] Vincent, Ém., Contribution a la paléontologie des falaises de Landana (Bas-Congo); Mollusques: *Musée Congo Belge, Annales*, sér. 3, tome 1, pp. 1–46, pls. 1–6, 1913.

[3] Gardner, Julia, Relation of certain foreign faunas to Midway fauna of Texas: *Am. Assoc. Petroleum Geologists, Bull.*, vol. 15, p. 158, 1931.

presumably very closely related to *H. orbiculata*, *H. diderrichi* to *H. ulrichi*, *Cimomia landanensis* to *C. subrecta*, and *C. vincenti* to *C. haltomi*.

The Landana hercoglossas, like those known from the Midway of the Gulf Coastal Plain, are very similar to *H. danica* of the Danian of northwestern Europe, and therefore it seems probable that the containing strata in these three widely separated localities are not greatly different in age. Also, Gardner[4] has called attention to the fact that the fauna of the lower Syzranian of the Volga Basin, European Russia, "contains a nautiloid of the *Hercoglossa danica* group"—the form referred to is *H. pavlowi* (Arkhanguelsky).[5] The figured type of that species appears to have been crushed laterally so that adequate comparisons with closely related species are not possible, but in so far as I am able to tell from the published illustrations, *H. pavlowi* is more closely similar to *H. ulrichi* of the Midway group than to any other form with which I am familiar.

The nautiloids ("*Nautilus* cf. *Deluci* d'Archiac") described by Oppenheim[6] from the Eocene of Togo and those described by Douvillé[7] from the Eocene of Sudan and Senegal (*Nautilus molli* and *N. chudeaui* from Sudan, and *N. senegalensis* from Senegal) are not closely related to the Landana forms; the shape of their sutures and the acute (or nearly so) venter of the mature whorls of their conchs indicate clearly that they should all be referred to Spath's genus *Deltoidonautilus*, of which *N. sowerbi* Wetherell of the London clay (middle Eocene) is the genotype. Furthermore, at least the strata which yielded the Sudan and the Senegal forms are distinctly younger than the Landana beds. The genus *Deltoidonautilus* is widespread in the Eocene of the Eastern Hemisphere but it has not been found outside of that series and no representative of it has been described from America.

SYSTEMATIC DESCRIPTIONS

CIMOMIA LANDANENSIS (Vincent)

Nautilus landanensis VINCENT [part], *1913*, Musée Congo Belge, Annales, sér. 3, tome 1, pp. 35–37, text fig., pl. 5, and possibly pl. 4, fig. 2 [but not pl. 4, fig. 1].

This species was established in 1913 by Vincent and was based on several specimens, three of which were figured. Vincent's illustrations are excellent and they show clearly that there is considerable variation among the cotypes; I am convinced that certain of these variations, particularly the degree of sinuosity of the sutures, are of specific value, and that the figured types of this species are not all conspecific. One of the cotypes is represented by two figures (Vincent's text fig. on p. 36, and his pl. 5), and I

[4] *Op. cit.*, p. 153.

[5] Arkhanguelsky, A. D., Dépôts paléocènes de la région volgienne du gouvernement de Saratov et leur faune: *Materialien zur Geologie Russlands*, Bd. 22, Lief. 1, pp. 171–172, pl. 22 (2 figures), 1904.

[6] Oppenheim, Paul, Die eocäne Invertebraten-Fauna des Kalksteins in Togo . . .: *Beitr. zur geol. Erforschung der Deutschen Schutzgebiete*, Heft 12, pp. 61–64, pl. 5, figs. 6*a*, 6*b*, 1915.

[7] Douvillé, H., L'Eocène au Soudan et au Sénégal: *Comité d'Études Hist. et Scient. de l'Afrique Occidentale Française, Bull.*, no. 2, pp. 138–143, pl. 1, fig. 1–5*b*, 1920.

am, therefore, choosing it as the holotype of Vincent's species—the other specimens illustrated are represented by only one figure each; one of them (Vincent's pl. 4, fig. 1) clearly represents the species described below as *Cimomia vincenti*, but I am uncertain in regard to the affinities of the other specimen (Vincent's pl. 4, fig. 2), for the nature of its sutures cannot be ascertained from the published illustration.

As thus restricted, *C. landanensis* can be briefly diagnosed as follows: Conch large (attaining a diameter of at least 38 cm.), subglobular, and nautiliconic. Living chamber at least one-third of a volution in extent. Whorls slightly depressed dorso-ventrally and subcrescentic in cross section as they are broadly rounded ventrally and laterally, abruptly rounded dorso-laterally, and rather deeply impressed dorsally; the impressed zone is almost one-third as deep as the conch is high. Umbilicus small; umbilical shoulders rounded and inconspicuous; umbilical walls steep. At maturity each external suture consists of a very broadly rounded ventral saddle, and on either side of it a much narrower (but nevertheless very broad) rounded lateral lobe and a similar lateral saddle which however is asymmetrical; there is in addition a moderately deep rounded lobe on the umbilical wall. Each internal suture consists of a very broadly rounded dorsal lobe and on either side of it a narrower rounded lateral saddle which extends to the lobe on the umbilical wall. Siphuncle small, circular in cross section, located about midway between the venter and the dorsum, and presumably orthochoanitic in structure.

Remarks.—The form of the conch and the shape of the sutures of this species indicate clearly that it represents the genus *Cimomia*, of which *Nautilus burtini* Galeotti of the Eocene of Belgium is the genotype. Vincent referred this species to the genus *Nautilus* but its sutures are not at all like those of *Nautilus pompilius* Linné,[8] the type of the genus *Nautilus*.

Cimomia landanensis is readily differentiated from *C. vincenti*, which occurs in the same general horizon and locality, by means of the relatively prominent lateral lobes and ventral saddles of its sutures; its sutures are much more strongly sinuous than are those of *C. vincenti* and also its conch apparently attains a greater size. The sutures of *C. subrecta* Miller and Thompson of the Midway (Clayton formation) of Mississippi are about equal in sinuosity to those of *C. landanensis*, but *C. subrecta* is a much smaller form, the dorso-lateral saddles of its sutures are relatively deeper, and the lateral lobes of its sutures center farther ventrad.

Occurrence.—Landana beds ("Paleocene"), Landana, Kabinda.

CIMOMIA VINCENTI Miller, n. sp.
Plate 19, figures 1, 2; text figure 1*A*

Nautilis landanensis VINCENT [part], *1913*, Musée Congo Belge, Annales, sér. 3, tome 1, pp. 35–37, text fig., pl. 4, fig. 1, and possibly pl. 4, fig. 2 [but not pl. 5].

Conch moderately large, subglobular in shape, and nautiliconic in its mode of growth; living chamber unknown but phragmacone attains a maximum diameter, measured from the adoral end of the venter across the umbilicus to the opposite side of the specimen, of at least 185 mm. Holotype, a well-preserved internal mold representing half of the outer? volution of the phragmacone, attains a maximum diameter of about 137 mm. At the adoral end of the holotype the conch is about 87 mm. high and about 116 mm. wide, whereas at the adapical end of this specimen it is only about 50 mm. high and 65 mm. (estimated) wide; it is clear from these figures that the conch expands orad fairly rapidly. Whorls are broadly rounded ventrally, only slightly flattened laterally, very abruptly rounded dorso-laterally, and rather deeply impressed dor-

[8] A diagrammatic representation of both the internal and the external sutures of *Nautilus pompilius* has recently been published by Miller and Thompson (*Jour. Paleontology*, vol. 7, p. 309, text fig. 2*G*, 1933).

sally. The impressed zone is almost twice as wide as deep and is about one-third as deep as the conch is high; at the adoral end of the holotype the impressed zone is about 30 mm. deep and about 57 mm. wide. Umbilicus small; umbilical shoulders low, rounded, and indefinite; umbilical walls steep.

Septa rather deeply concave. Their spacing is somewhat irregular but along the venter the distance between successive sutures averages about one-fourth the maximum width of the conch. Surface of internal mold, at least, smooth and entirely devoid of markings other than the sutures. Each suture, though nearly straight on the ventral and ventro-lateral sides of the conch, forms a very broad and very shallow (easily overlooked) ventral saddle and on either side

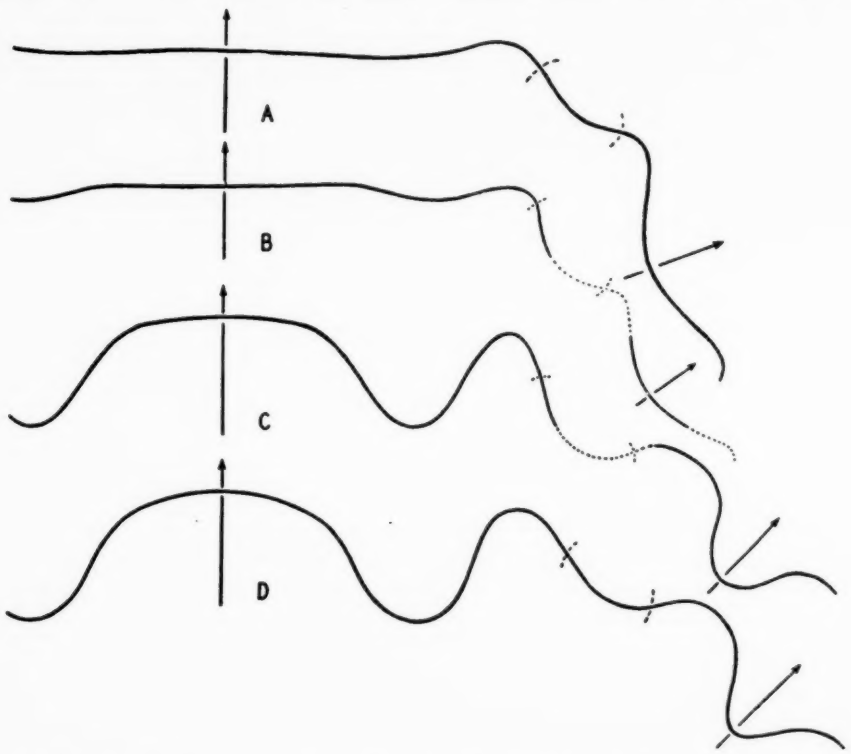

FIG. 1—Diagrammatic representations of sutures of mature stages of:
A, *Cimomia vincenti* Miller, n. sp., based on the holotype, ×4/7.
B, *Cimomia haltomi* (Aldrich), based on a topotype, ×3/4.
C, *Hercoglossa clarki* Miller, n. sp., based on the holotype, ×2/7.
D, *Hercoglossa orbiculata* (Tuomey), based on the neoholotype, ×2/7.

Cimomia vincenti and *Hercoglossa clarki* are from the "Paleocene" (Landana beds) of western Africa whereas *C. haltomi* and *H. orbiculata* are from the Midway group of Alabama.

EXPLANATION OF PLATE 19

FIGS. 1, 2—*Cimomia vincenti* Miller, n. sp. Dorsal and lateral views of the holotype, from the "Paleocene" (Landana beds) of Landana, Kabinda, ×4/5. (p. 169)

2

1

Miller, "Paleocene" Nautiloid Cephalopods

of it a similar but narrower lateral lobe, a relatively high prominent dorso-lateral saddle which centers just outside (ventrad of) the umbilical shoulder, a broad shallow broadly rounded lobe on the umbilical wall, and a broad relatively deep and narrowly rounded saddle which is located on the lateral side of the impressed zone and which extends to the broad rather shallow rounded dorsal lobe (see text figure 1A).

Siphuncle small, circular in cross section, located about midway between the venter and the dorsum, and apparently orthochoanitic in structure. At the adoral end of the holotype the siphuncle is about 5 mm. in diameter.

Remarks.—The above description is based largely on the holotype but also in part on Vincent's figure of a larger specimen from the same general horizon and locality (a topoparatype). The holotype is composed of light-gray foraminiferal limestone which is somewhat mottled on the surface by yellowish brown stains.

As mentioned above in the discussion of *Cimomia landanensis* (Vincent), the three figured cotypes of that species show palpable differences and in my opinion they are not all conspecific; one of them (Vincent's plate 4, fig. 1) clearly represents the species under consideration, *C. vincenti*, and another (Vincent's plate 4, fig. 2) may represent it but since the nature of its sutures cannot be ascertained from the published illustration I am uncertain in regard to its affinities. *C. landanensis* s. s. differs from *C. vincenti* in that the sutures of the former are much more strongly sinuous and form much deeper lateral lobes and ventral saddles than do those of *C. vincenti*, and in addition the conch probably attained a much greater size. *C. vincenti* is much more closely similar to *C. haltomi* (Aldrich) of the Midway (Sucarnochee clay = Porters Creek clay) of Alabama, but the ventral and lateral parts of its sutures are even less strongly sinuous than are those of that form (see text figure 1) and the conchs of the two species are not precisely similar in shape.

Occurrence.—Landana beds ("Paleocene"), Landana, Kabinda.

Repository.—State University of Iowa, Catalog No. 715 (holotype).

HERCOGLOSSA DIDERRICHI Vincent

Hercoglossa diderrichi VINCENT, *1913*, Musée Congo Belge, Annales, sér. 3, tome 1, pp. 37–39, pl. 6, figs. 1–3.

Hercoglossa (Cimomia) diderrichi SCOTT, *1934*, Geol. Soc. America, Bull., vol. 45, p. 1150, pl. 134, fig. 4.

Only a single representative, the holotype, of this species is known. It has been well described and beautifully illustrated by Vincent. In size and shape it is comparable to *H. ulrichi* (White) of the Midway group of North America but it is less narrowly rounded ventrally, its siphuncle is more nearly ventral in position, and its sutures present significant differences particularly in that the ventral saddles are blunt and the lateral lobes are distinctly narrower than the dorso-lateral saddles. *H. diderrichi* appears to be very similar and therefore presumably very closely related to *H. danica* (Schlotheim) [as figured by Lyell[9] and Ravn[10]] of the Danian of Faxe, etc., for in that species the dorso-lateral saddles of the sutures are broader than the lateral lobes and the conch is rather broadly rounded ventrally. *H. diderrichi* is not conspecific with *H. danica*, however, for the ventral saddles of its sutures are blunter, its siphuncle is more nearly ventral in position, and its conch appears to be more rapidly expanded orad particularly in a lateral direction; also all of the topotypes of *H. danica* that have been figured are much smaller than the holotype of *H. diderrichi*.

Occurrence.—Landana beds ("Paleocene"), Landana, Kabinda.

[9] Lyell, Charles, On the Cretaceous and Tertiary strata of the Danish islands of Seeland and Moen: *Geol. Soc. London, Trans.*, ser. 2, vol. 5, pl. 18, figs. 4–7, 1837.

[10] Ravn, J. P. J., Molluskerne i Danmarks Kridtaflejringer; II, Scaphopoder, Gastropoder og Cephalopoder: *Mus. Min. et Géol. l'Univ. Copenhague, Comm. Pal.*, no. 2, pl. 4, figs. 3–4, pl. 5, fig. 3, 1902.

HERCOGLOSSA CLARKI Miller, n. sp.
Plate 20, figures 1, 2; text figures 1*C*, 2

Conch, which apparently consists of several volutions, is large and is nautiliconic in its mode of growth. The holotype and only known representative of the species is a well preserved internal mold that represents much of three chambers of the outer? volution of the phragmacone. The nature of the living chamber is not known but the phragmacone attained a maximum diameter of at least 20 cm.

The whorls are somewhat flattened laterally, rounded ventrally, and impressed dorsally; the lateral sides converge toward the venter. The maximum width of the conch, which is attained just ventrad of the umbilical shoulders, is slightly greater than the maximum height. At the adoral end of the holotype the conch is about 157 mm. high and 165 mm. (estimated) wide, and the dorsal impressed zone is about 53 mm. deep and 80 mm. wide. The lateral sides of the impressed zone are nearly straight (slightly concave) and the dorsal side is evenly rounded. The junctions of the lateral sides of the impressed zone with the umbilical walls are narrowly rounded. Umbilicus small; umbilical shoulders rounded but nevertheless fairly distinct. Umbilical walls nearly straight (slightly convex) and inclined to the flattened lateral sides of the conch at an angle of a little more than 100 degrees.

Surface of internal mold smooth and marked by only the sutures. Each suture forms a very broad deep blunt ventral saddle, and on either side of it a broad deep rounded depressed-U-shaped lateral lobe, a similar but narrower and much more narrowly rounded dorso-lateral saddle, a broad shallow broadly rounded lobe on the umbilical wall, and a similar but deeper saddle located on the lateral side of the impressed zone and extending to the dorsal lobe which is almost V-shaped but is narrowly rounded and has slightly curved sides. Along the venter the distance between successive septa is equal to almost half the maximum width of the conch, but along the dorsal flanks of the lateral lobes adjacent sutures are very close together. The septa are not greatly curved transversely but they are asymmetrically sigmoidal dorso-ventrally as their ventral portion is curved strongly orad and their extreme dorsal portion is curved strongly apicad.

Siphuncle small, composed of cylindrical segments, and orthochoanitic in structure. It is located almost midway between the center and the venter. At the adoral end of the holotype the siphuncle is about 6 mm. in diameter and is located about 40 mm. from the venter, about 60 mm. from the bottom of the impressed zone (the dorsum), and about 115 mm. from the extreme dorsal portion of the conch.

Remarks.—The above description is based on a single well preserved specimen which is composed of yellowish white limestone but is somewhat mottled on the surface by brown stains. The specific name is given in honor of Prof. T. H. Clark of McGill University, Montreal, who sent me the specimens on which this paper is based.

Hercoglossa clarki differs from *H. diderrichi*, which also occurs in the Landana beds, in that its whorls are lower and broader and more broadly rounded ventrally, its siphuncle is less nearly ventral in position, and its sutures present palpable differences particularly in that the lateral lobes are broader and more broadly rounded than are the dorso-lateral saddles whereas in the sutures of *H. diderrichi* the reverse is the case. *H. clarki* is much more similar and therefore presumably much more closely re-

EXPLANATION OF PLATE 20

FIGS. 1, 2—*Hercoglossa clarki* Miller, n. sp. Lateral and ventral views of the holotype, from the "Paleocene" (Landana beds) of Landana, Kabinda, ×3/5. (p. 172)

1 2

Miller, "Paleocene" Nautiloid Cephalopods

lated to *H. orbiculata* of the basal Midway (Clayton formation) of Alabama, but as is obvious from the accompanying text figures (1, 2) its conch is distinctly lower and broader and is more broadly rounded ventrally and the ventral saddles and dorsal lobes of its sutures are blunter than are those of *H. orbiculata* whereas the dorso-lateral saddles and lateral lobes are sharper.

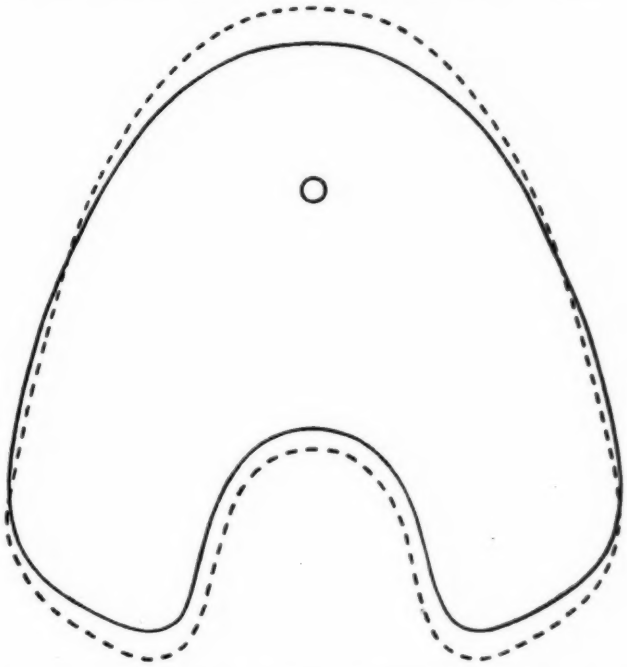

FIG. 2—Diagrammatic cross sections of *Hercoglossa clarki* Miller, n. sp., of the "Paleocene" (Landana beds) of western Africa and *H. orbiculata* (Tuomey) [dotted] of the Midway (Clayton formation) of Alabama, both ×1/2. The siphuncles on these two diagrams coincide.

Occurrence.—Landana beds ("Paleocene"), Landana, Kabinda.

Repository.—State University of Iowa Catalog No. 716 (holotype).

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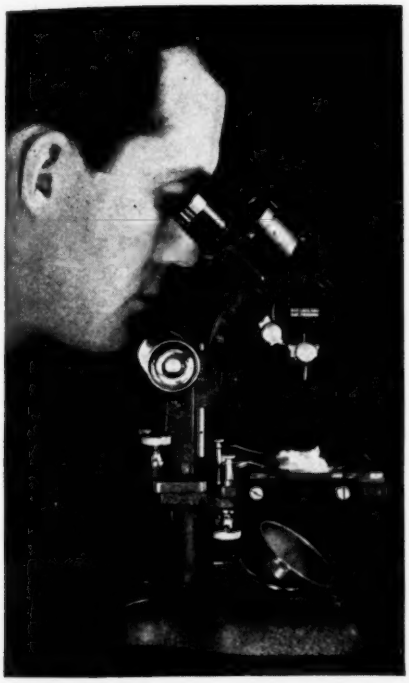

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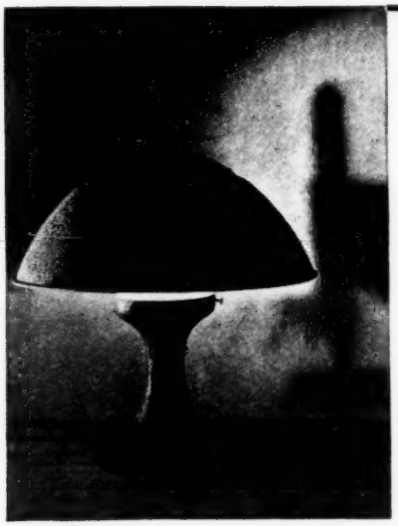

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